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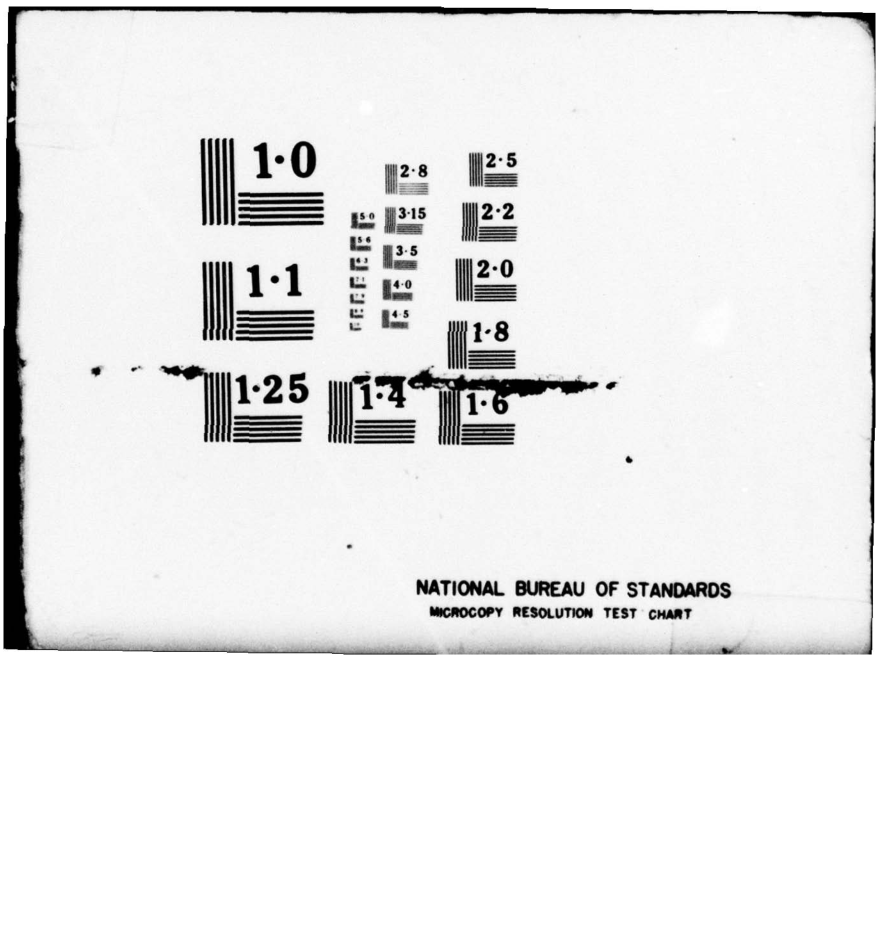
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FIBER OPTICS APPLICATIONS STUDY

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29 April 1977

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Candidate applications for fiber optics in the TRITAC network are identified and sufficient technical data presented in support of the selection of the AN/TTC-39 intershelter cabling application for further feasibility development.

During the initial phase of this study, the overall TRITAC network was examined and several potential applications identified and categorized. next page

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This list of applications was ranked in order of desirability according to criteria developed during the course of the study. Upon review and concurrence by ECOM, the ANTTC-39 intershelter application was selected and a detailed study made leading to preparation of the performance requirements for a subsequent feasibility development.

These requirements include electrical and mechanical interface characteristics, multiplexing techniques, optical link design and performance requirements in sufficient detail to allow preparation of a specification for an exploratory developmental model.

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SECTION 1

INTRODUCTION

Significant advances in fiber optics technology have been made in industrial and DoD research laboratories during the past few years. The technology has reached a state of maturity sufficient to establish it as a viable contender, along with the other more conventional transmission techniques, for use in systems that are currently in the design and development stage. Intensive efforts are being made by the common carriers to develop the requisite system elements and to build demonstration and field trial models of fiber optic carrier systems. The DoD laboratories are now undertaking intensive efforts to facilitate the early introduction of fiber optics for military communications.

Since 1975, GTE Sylvania has been engaged in a study of potential applications of fiber optics to the TRITAC network. Through a prime contract for the AN/TTC-39 and a subcontract for the Digital Group Multiplex (DGM), GTE Sylvania is fully cognizant of the philosophy, architecture, design, and operational characteristics of the total communication network. This experience, coupled with an extensive capability in fiber optic components and systems design, bring a unique combination of resources to this study. The fiber optic expertise is afforded by the continuing research and development effort that has been in progress for over five years at GTE Laboratories.

The objectives of this study were to identify candidate applications for fiber optics in the TRITAC network and to develop sufficient technical data to allow ECOM to prepare a functional specification for a feasibility model. During the initial phase, the overall TRITAC network was examined to identify and categorize the potential applications. This phase concluded with the preparation of a ranked list of applications based upon evaluation criteria developed during the course of the study. Upon review and agreement with ECOM, a detailed study of a specific application was undertaken leading to the performance requirements for a feasibility model.

This report includes the electrical and mechanical interface characteristics, multiplexing techniques, optical link design, and performance requirements for the selected application in sufficient detail to allow preparation of a development specification for future procurement of an exploratory development model. It also includes all identified applications of fiber optic communications technology in their ranked order of desirability, results of the trade-off analysis associated with each possible application, and all other data generated in the investigation relevant to the decision as to which possible application to study in detail. Lastly, it contains the recommendations by GTE Sylvania for future detailed application investigations.

This final technical report is being submitted in full compliance with the requirements of ECOM Development Specification No. DS-EN-0224A(A) of 15 April 1976 that constitutes the Description/Specification section of ECOM Contract Number DAAB07-76-C-0049.

SECTION 2

SUMMARY

This section contains a description of the approach taken for performing this study, the results and conclusions obtained therefrom, and recommendations by GTE Sylvania for future application studies and/or developments.

2.1 GENERAL

The sequence of material contained in this report generally follows the order of work performed. Section 3 describes the steps leading to the selection of the application to be studied in detail. The objectives of the study are set down, together with the assumptions necessary to bound and yet provide wide area to the scope of the investigations. Guidelines are then presented for selecting potential applications that both complement TRITAC needs and make use of various fiber optic attributes.

Within these guidelines, the AN/TTC-39 interfaces were reviewed and their characteristics set down. A number of fiber optic alternatives were then selected that offered desirable and potentially superior performance features or cost benefits. Typical configurations were developed for these alternatives and their corresponding characteristics defined. Using real or relative costs and performance criteria as defined, the fiber optic alternatives were assessed according to a scoring/weighting methodology and ranked according to desirability for feasibility development. Upon presentation of the results to and concurrence by ECOM, a detailed study of the selected application was made.

This detailed study is presented in Section 4 and contains sufficient data for preparing a subsequent feasibility model work statement. A review is first presented of the present means for implementing the required function, followed by a description of the fiber optic alternative. The physical and electrical interface characteristics are then presented, together with the performance requirements necessary for proper interaction with respective elements of the AN/TTC-39 switch. The detailed data forming the basis for this study are contained in several appendices.

2.2 RESULTS/CONCLUSIONS

During this applications study, a total of fourteen potential fiber optic alternatives to pres^nt techniques were identified as candidates for further feasibility development. In order to measure the relative desirability of each alternative for such subsequent efforts, a list of categories was prepared that contains characteristics generally used for such purposes. The list is as follows:

1. EMP/EMC/EMI
2. Cross-talk Immunity
3. Physical Size
4. Weight
5. Power Requirements
6. Signaling/Supervision
7. Reliability
8. Maintainability
9. Modularity
10. Setup/Teardown
11. Security
12. Acquisition Cost
13. Operation/Maintenance Cost

A weighting was applied to reflect the importance of these categories to each of fourteen alternatives. The weighted sums were then determined and the results normalized to yield a ranked list of the alternatives in terms of desirability for further study. The ranked list is shown below:

1. Digital Trunks
2. Analog Loops (TDM)
3. Digital Loops (MUX)
4. MS-MS (TDM)
5. Analog Trunks (FDM)
6. Intershelter (LKG)
7. Digital Loops (One-One)
8. MS-CS

9. MS-MS (One-One)
10. Intershelter (I/O)
11. Intershelter (C/S)
12. Analog Loops (PCM)
13. Analog Loops (FDM)
14. MS-MS (inventory TDM)

Following presentation of the above results to, and with concurrence of, ECOM, the three intershelter alternatives were selected as a single application for the balance of this study. A detailed evaluation was made of the selected application which resulted in the generation of design guidelines sufficient for preparation of a feasibility model. These design guidelines for the intershelter fiber optic application form the baseline for follow-on investigations.

One of the most significant conclusions that arose during the study was that applications having digital formats in multiplexed form were favored over others. This was evident in the case of the highest ranked application, namely that involving digital trunks, an area already under feasibility development by ECOM. The functional attributes of such applications lending themselves particularly well to fiber optic alternatives were simplicity of circuitry and compatibility of bandwidth requirements with those available with optical fibers.

Higher ranking was attained by applications involving loop or subscriber interconnections, primarily because of the great savings in physical size and weight over conventional wire techniques. The principal application in the area of analog loops, in addition to great potential, has associated great problems, however. The requirement of both Local Battery and Common Battery operation, in turn, necessitates the requirement for dc power, supplied either via the loop or remote power sources. Dc power cannot be transmitted via the optical fiber (except by adding a conductor), and additional remote power requirements involve deployment considerations beyond the scope of this study. Other associated problems include an optical drop-and-insert capability that is not within the state of current fiber optic technology. An alternative

approach, using space-division techniques, is presently being considered wherein some fibers in a multi-fiber cable are used for intermediate-distance subscribers. This technique may result in an inefficient utilization of the available bandwidth, however, or may impose assignment requirements that could restrict general usage.

Specific cost data was found to be not readily available, primarily because of the lack of generally accepted cost models. The life cycle cost model for the AN/TTC-39 has been exercised considerably during several trade-off studies, and has been examined both by GTE Sylvania and TRITAC for bias. The existence of this acceptable cost model is not surprising, since the AN/TTC-39 is the first TRITAC component to be procured of a long list of others. This model includes the switching and control shelters, support pallets, interconnecting links, environmental control equipment and transportation units for the AN/TTC-39, but does not include any transmission media beyond the junction boxes. In order to generate cost data for loop and trunk applications, GTE Sylvania would have to postulate an appropriate scenario and defend it before the user communities. The problems involved in this operation are often other than technical because of the often-conflicting requirements of the various services in the switching area.

The approach finally selected for detailed study circumvents many of these problems. Its terminals are at shelters that can provide power in either or both directions. Performance criteria in most cases are well specified, facilitating trade-offs and compatible fiber optic design guideline specification. The cost model allows an acceptable cost trade-off to be made.

Lastly, the selected application was found to be relatively unaffected by particulars of fiber optic technology; its position in the ranking order and the details of the fiber optic design were functions mainly of the interfacing hardware associated with this application.

2.3 RECOMMENDATIONS

At the conclusion of this study, two types of recommendations can be made; those with respect to the detailed application with hindsight, and those with respect to other potential applications with judicious foresight.

First of all, a one-for-one replacement of cables of conductors by optical fiber alternatives does not facilitate a feasibility study. As is often the case, spare transmission paths in multi-conductor cables, that are valid for engineering considerations, are used to carry functional signals completely unrelated to those for which the cable was originally designed. Therefore, analog and digital formats are intermixed with dc, ac and dry-contact signals that make reduction to a common baseline difficult for fiber optic implementation. On the other hand, assignment of these different formats to individual fibers can result in inefficient utilization of available bandwidth.

The detailed application described herein consists of three sub-links, namely, the Loop Key Generator (LKG), Processor Input/Output (I/O) and Control/Status (C/S) sub-links, all of which exhibit this intermixing to some extent. The LKG sub-link is the least "cluttered", primarily because of the well-defined system role played and the specific characteristics of the Government-supplied equipment used. In addition to the input/output functional signals, the I/O sub-link also carries status signals of a low-priority nature that, in a revised design, might have been placed in another cable. The majority of signals are I/O-related, however, because of the well-defined role of the control processor supplied by a GTE Sylvania sub-contractor to a definite specification. The C/S sub-link contains the bulk of the "catch-all" functions, ranging from analog and digital voice data to control and status levels and others of similar types. Moreover, in the on-going switch development program, the firm commitment of conductors and/or functions within the present cable set has not been made to the same degree as that for the preceding sub-links. The status of development for each of these sub-link presents varying problems to a feasibility development program.

Therefore, GTE Sylvania recommends that, if a selection of one or more of the sub-links in the intershelter application be desirable, preference be given to the LKG and I/O sub-links as prime candidates for further feasibility studies. At some future time, when an engineering change to optical fiber intershelter communications is being made, and when consolidation of like functions to specific transmission paths can be achieved, the C/S sub-link will then become an attractive application.

On that point alone, GTE Sylvania recommends a further study to determine various re-configuration alternatives that would facilitate the change-over from conductors to optical fibers, with the additional freedom of altering present wiring paths and points of interface. The point of view to be used in this instance is that of re-examining the entire intershelter interconnectivity for optimal employment of fiber optics similar to that used in initial conceptual design. This type of study would have to be performed, if only to satisfy cost-effectiveness objectives, prior to incorporation of changes to the newer technique, and would be the natural follow-on step to the feasibility study toward which this program is directed. Furthermore, such a study has minimal impact on the results of this study, because the conductors associated with the recommended sub-links are already closely related with the functions performed. The basic problem remaining appears to center around relocation of functions within the same transmission path and determining how best to multiplex the resulting groups for transmission over optical fiber links.

GTE Sylvania recommends re-evaluation of the analog loop application for a number of reasons. First, the greatest savings in size and weight of optical fibers over conventional techniques occurs for this application. The potential for such reductions is significant both for the AN/TTC-39 switch and for the substantially greater field loop plant. Although there is still some resistance in the military user community to techniques other than field wire and coaxial cable, the TRITAC impetus will eventually bring about changes in philosophy. These will include new deployment concepts whereby the problems of power sources and subscriber concentration will be solved in ways offering great attraction for fiber optic techniques. As an example, the current fielding of switchboard SB-3614 provides for concentrating multiple analog subscribers at distances of several kilometers from the AN/TTC-39 switch, and offering both Local Battery and Common Battery services. The concept of providing such power at points of concentration solves power distribution problems associated with optical fiber communication without interfering with its EMP/EMI/EMC advantages. While it may be argued that this approach places an additional burden on the logistical problem of supplying such power, the

fielding of this equipment will force suitable solutions to these problems. The flexibility of a drop-and-insert capability for optical fibers will be solved in the near future because industry has a strong interest in this problem for commercial purposes, such as multi-drop and multiple-access systems. This application would require two functions: one for replacing the conventional modem by its optical counterpart, and the other for providing A/D conversion for simplifying the interfacing circuitry. The latter function is currently available from commercial sources in integrated circuit form at relatively low cost. An equivalent military version should be forthcoming in the near future, making the transition an easy one to accomplish.

GTE Sylvania also recommends a detailed study of the digital loop application, which employs digital subscriber concentrators similar to that just described for the analog case. The Unit Level Circuit Switch development contract will begin in the very near future; therefore, a soon-to-be-fielded equipment will join the military inventory and solve powering problems that might preclude optical fiber techniques. In addition, development of the Digital Group Multiplex has been completed and equipments will undergo field testing shortly. These equipments provide added flexibility for implementing various deployments of subscribers, and offer opportunities for fiber optic techniques that are complementary to those of the ULCS. GTE Sylvania views this application as one in which a fiber optic modem replaces a conventional modem on a card-for-card basis. Current military procurements require circuit cards as minimum-replaceable items for facilitating maintenance and repair; these in turn can be replaced by their optical counterparts. Furthermore, standardized card design allows a single general-purpose optical modem to serve a wide variety of equipments in a modular fashion. The use of less costly LED and PIN components should allow transmission over distances greater than that possible with current equipment, without incurring cross-talk problems or need for repeaters. Therefore, this potential application does not conflict with the study currently concerned with long-haul digital transmission over the entire military digital spectrum.

SECTION 3

EVALUATION OF POTENTIAL FIBER OPTIC APPLICATIONS

This section describes the approach taken for performing the subject fiber optics applications study. It contains the following elements:

1. Identification of the study objectives
2. Formulation of assumptions
3. Selections of alternatives that meet the objectives
4. Determination of the costs and benefits of each alternative
5. Comparison of the alternatives
6. Testing of the sensitivity of major uncertainties on the outcome.

Each of these elements will be addressed in detail in the succeeding subsections.

3.1 STUDY OBJECTIVES

The objectives of this study are to identify and describe those areas in the TRITAC system that could benefit most from the application of fiber optics technology. In particular, candidate applications for fiber optics will be identified and sufficient technical data developed to allow such applications to be ranked according to desirability. Upon review and concurrence by ECOM, a detailed study of a specific application will be undertaken leading to the performance requirements for a feasibility model.

3.2 FORMULATION OF ASSUMPTIONS

Assumptions are necessary for placing reasonable bounds on the scope of the study. In this regard, there are two points that require qualification, namely:

1. The area of investigation within the overall TRITAC system that allows identification of a sufficient variety of applications, and
2. The selection of fiber optic alternatives to such applications that best make use of developing technology and current military inventory.

Therefore, a brief overview of a typical TRITAC deployment is presented, followed by those assumptions that bound the investigation to areas within which GTE Sylvania can bring its experience most fruitfully to bear.

In addition, current and projected trends in fiber optics and related developments are noted, together with those assumptions that incorporate such trends into the selection of fiber optic alternatives.

3.2.1 Scope of the Study Area

3.2.1.1 The TRITAC Network

The backbone communications system supporting the operational elements of Joint/Component forces in a tactical area is configured in a grid network comprising nodes that include operational elements within the nodal area and transmission systems (LOS, HF, Tropo, Satellite) that interconnect or link the nodes so that the communications requirements within the tactical area of operation are satisfied. Figure 3-1 illustrates the major communications elements (cable/LOS transmission systems; circuit/message switching systems; node/system control elements; radio systems that provide internodal links) that may exist within a tactical mode. An actual nodal layout would be a function of the node's role in a deployment of forces and might include, for example, several switching centers (AN/TTC-39 and/or inventory systems, e.g. AN/TTC-38). Conversely, the node might be a transmission node without switching systems and associated local/remote subscribers.

The communications elements dispersed within the illustrative node shown in Figure 3-1 are interconnected by cable transmission systems (coaxial, twisted pair), or by line-of-sight (LOS) interconnections where the use of cable is precluded. Cable distances range from tens of meters in the case of colocated shelters to tens of kilometers in the case of outlying users at extension facilities. Actual intranodal cable (or LOS) interconnectivity would be a function of the siting of the communications elements, technical limitations on maximum cable distance and the placement of operational elements, e.g., a Tactical Air Base, within the nodal area. The interconnectivity pattern of Figure 3-1 shows the types of interconnections associated with the AN/TTC-39 switch system. The TTC-39 circuit switch (CS) requires intercabling

TACTICAL NETWORK NODE COMMUNICATIONS ELEMENTS CONNECTIVITY (Illustrative)

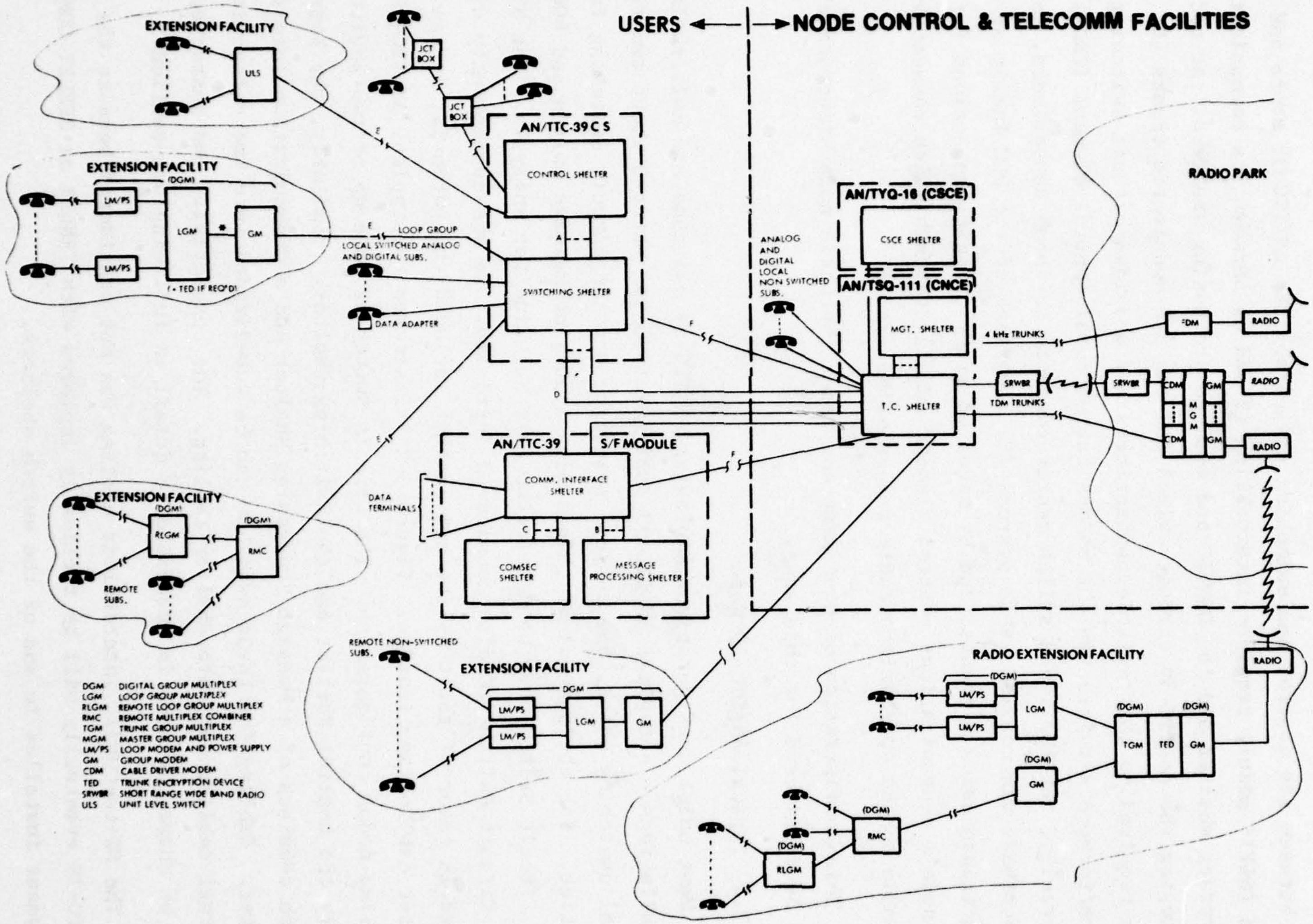


Figure 3-1. Tactical Network Node Communications Elements Connectivity (Illustrative)

(A) between its control and switching shelters. The AN/TTC-39 store and forward (S&F)* module requires intercabling (B and C) between its communications interface shelter and its COMSEC and message processing shelters. At nodes employing the AN/TTC-39 circuit switch and the S/F module, tie trunks (D) are also required so that switched subscribers are provided circuit switching and store/forward services via the communication nodal control element (CNCE). Externally, the AN/TTC-39 switch center connects to local subscribers, to remote subscribers via coaxial cable systems (E) comprised of the DGM family of multiplex/transmission elements, and by required trunk circuit connections (F) to the node's communications control element (CNCE), through which connections are made to the appropriate radio transmission system.

This configuration of equipment comprises the basic node structure that will be considered for this study.

3.2.1.2 Typical AN/TTC-39 Node

Most nodal configurations employing AN/TTC-39 switches are multishelter installations. A typical AN/TTC-39 configuration is centered about two functional switching units, the message switching and the circuit switching facilities. For the purpose of this study, a 50-line Message Switch and 600-line Circuit Switch have been selected as a baseline for analysis. The 300-line Circuit Switch was also considered initially. It was subsequently discarded in favor of the 600-line switch that included the potential intershelter cabling application. Figure 3-2 illustrates the typical AN/TTC-39 600-line nodal configuration. The Circuit Switch is made up of two shelters, namely the Control Shelter and the Switching Shelter. Similarly, the Message Switch consists of a Message Processing Shelter and a Communication Interface Shelter. Cabling for these switches can be sub-divided into two categories: external cabling and intershelter cabling. The connectivity and characteristics of these shelters is described in detail in following sub-sections.

The MS-to-COMSEC intershelter cabling was not considered because the AN/TTC-39 eventually will be tactically deployed with TENLEY or SEELEY COMSEC equipment installed in one of the switch shelters.

*The Store-and-forward module is also referred to as the message switch, MS.

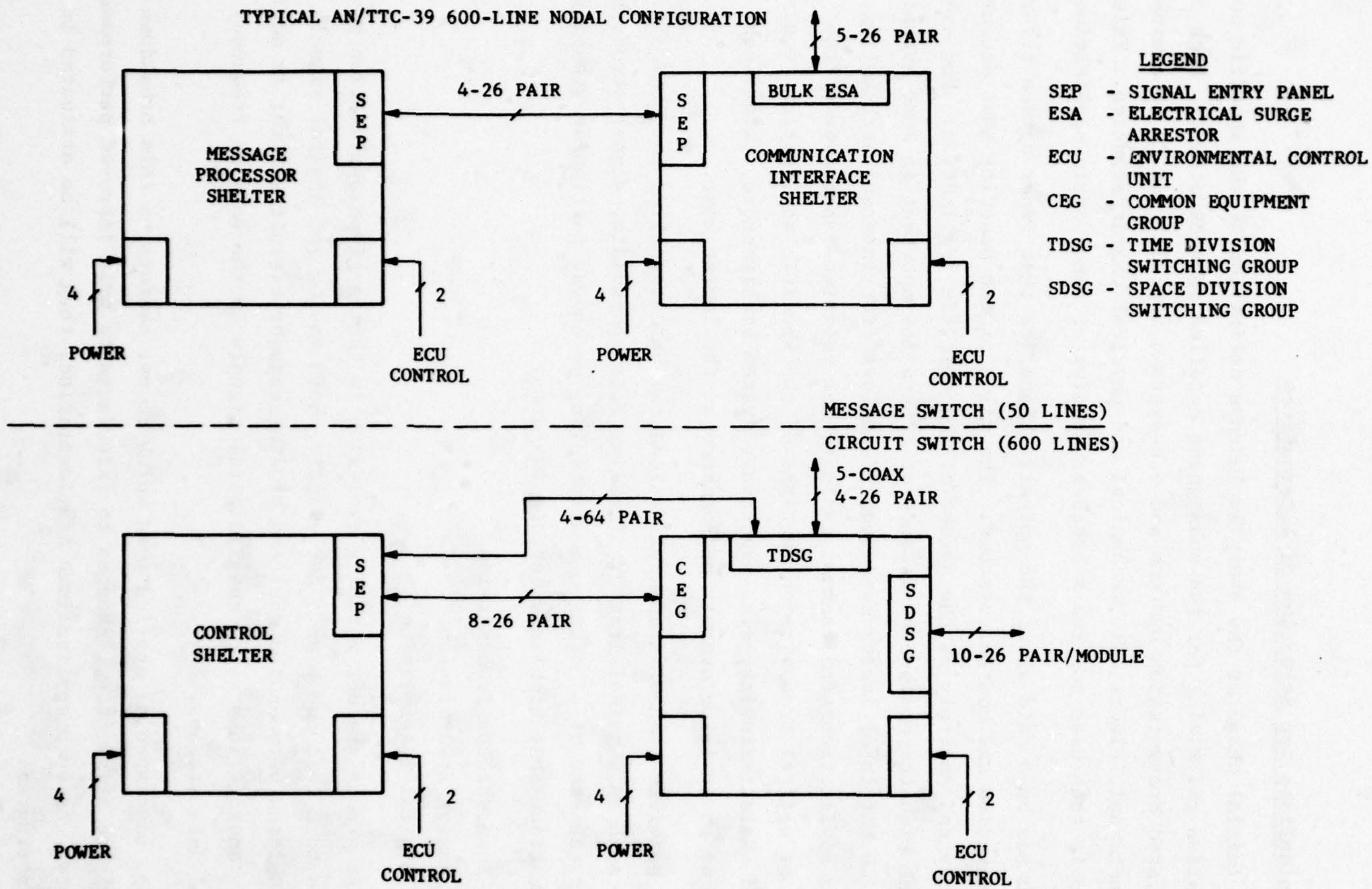


Figure 3-2. Typical AN/TTC-39 600-Line Nodal Configuration

3.2.2 Guidelines for Selection of Alternatives

The initial phase of the study includes a definition of the specific nodal configuration and sizing for the subsequent detailed consideration. Each of the indicated transmission systems and sub-systems are analyzed to determine their functional, electrical, mechanical and physical characteristics. This data base is then used for the subsequent studies of fiber optic applications.

Much has been said about the potential benefits that fiber optics offer to communication and control systems. The value of the benefits that accrue, however, depend entirely on the nature of the specific application. For example, the high temperature resistance of fibers is important in some avionic application but is of lesser consequence when used for intershelter cabling. Thus, the application studies must evaluate the relative importance of the features of optical transmission in terms of the specific application requirements and characteristics, e.g., doctrine, system architecture, interfaces, etc., so as to optimize overall performance at the lowest cost.

The possible transmission applications can be categorized in terms of features such as physical length, signaling rate, bandwidth, signal structure, etc. For the sake of a background discussion, we choose particular groupings of applications that highlight certain features:

Intershelter Transmission
Analog Transmission
Digital Transmission

These groups are not mutually exclusive in that a given application may fall into more than one area. For example, both analog and digital signals are transmitted between the shelters of a message or circuit switch; in addition, the analog links carry quasi-digital signals in the form of frequency modulated data streams.

Also, some special applications which do not conform to this breakdown are likely to arise, e.g., changes to interfaces to gain improved performance capability. As such applications are identified, they will be evaluated in the study program.

Fiber optic technology becomes an attractive alternative to other techniques in those areas where its benefits can best be applied. Some of the benefits considered during this study are:

a. EMI and cross-talk immunity
b. Security - no signal leakage
c. Large bandwidth for size and weight
d. Small size, light weight - ease of installation
e. Potential of low cost
f. No electrical ground problems
g. No short circuits
h. No ringing problems
i. Potential for reducing total system power requirements
j. High temperature tolerance (500-1000^{o}C)
k. High tensile strength
l. No copper (strategic material)
m. Potential nuclear radiation resistance

The first items indicate that optical fibers neither radiate nor respond to electromagnetic energy. Wire conductors, on the other hand, are protected against such influences by means of filters, shields and surge arrestor devices. Therefore, the use of fiber optics should be directed toward those applications in which one or more of these protective devices can be eliminated. Benefits may be realized in terms of lower costs, fewer components, and reduced size and weight.

The first item also indicates that optical energy transfer between fibers is minimal. Fiber optics thus finds application in those areas where transmission distance is limited by near-end crosstalk. The distance limitation for optical fibers is more closely related to the far-end crosstalk problem because of accumulation effects, yet this limitation allows greater transmission distances for a given bandwidth than either twisted-pair or coaxial conductors.

The higher bandwidth capability suggests that serial rather than parallel transmission be employed with its attendant benefits of fewer transmission paths, albeit at the expense of added equipment. Such equipment includes

multiplexers (analog and digital), A/D converters, serial/parallel converters, and the like. Although cost savings realized from fewer conductors is partially offset by increased equipment costs, such costs are being reduced especially in the digital area. LSI and MSI techniques have brought about significant savings in the costs of the functions previously described. Furthermore, the general trend for military communications is toward an all-digital format. This "pressure" will undoubtedly bring about further cost improvements even in the heretofore all-analog areas. Therefore, the use of fiber optics should be considered in those areas where a reduction in the number of wire conductors can be realized.

Even in the case of a one-for-one replacement of wire by opitcal fiber, the decreased size and weight leads to reduced transportation, installation, maintenance, and logistical costs, all of which must be considered for support of a major military communications system such as TRITAC. These cost savings can be realized in terms of lower transportation weight, fewer vehicles and support personnel, shorter set-up and tear-down time, and reduced spares and facilities. Therefore, barring any communication incompatibility, the use of optical fibers should be directed toward direct replacement of existing conductors.

One electrical property that is both a benefit and a liability is the inability of optical fibers to conduct electrical current. In a wire system, conductors can be used both for signal and power transmission, the latter being of importance for powering remote terminals and repeaters. Optical fibers, on the other hand, can only communicate the signal information, but the inability to conduct current prevents "ground loop" situations and provides high electrical isolation between communicating equipments. In the proper application, the use of fiber optics can provide the benefit without the incurred liability, as in the case of non-powered transmission lines. In other situations where power is required, the alternatives of including a colocated wire conductor or remote power source must be considered.

The remaining benefits are related to the physical properties of optical fibers, and are obvious in the proper application.

3.3 SELECTION OF FIBER OPTIC ALTERNATIVES

The term "fiber optic alternative" will be used herein to designate a candidate application for the subsequent detailed study contained in Section 4 of this report.

The AN/TTC-39 system provides switchable interconnection between multiple subscribers having a wide variety of terminal equipments. The selection of particular alternatives should not result in degradation of AN/TTC-39 system performance. Therefore, a detailed review of the characteristics of the various terminal equipments was performed to prevent such degradation, however inadvertent. Results of the review are contained in the following paragraphs, together with the selection of alternatives that both incorporate optical fiber advantages and maintain system performance.

3.3.1 AN/TTC-39 Equipment Interfaces

The Circuit and Message Switch interfaces comprise all of the various types of lines that are external to one or both shelters, including those that interconnect the shelters themselves. In the case of the Circuit Switch, these types include both analog and digital loops and trunks plus the intershelter links. In the case of the Message Switch, they include both dedicated and switched lines and trunks, intershelter links and, for convenience only, the links that interconnect the two switches themselves.

Table 3-1 contains lists of the various equipments that interface with the Circuit and Message Switches. As can be seen, the greater variety occurs in the case of the Circuit Switch, primarily because of its role of interconnecting the numerous analog terminal equipments in the current military inventory.

A complete description of the characteristics of each of these line types is contained in Appendix E; the list of characteristics is shown below:

1. Type of line
2. Maximum information frequency
3. Duty cycle
4. Type of modulation

TABLE 3-1 CIRCUIT SWITCH INTERFACES

ANALOG			DIGITAL		INTERSHELTER
LOOPS	TRUNKS		LOOPS	TRUNKS	LINKS
TA-341	AUTOVON	CV1919	KY-68 (DSVT)	DIGITAL DCS	PROCESSOR IOX INTERFACE
TA-720	NATO	CV1918	TA ( ) (DNVT)	TRI-TAC SWITCHES	LINK KEY GENERATOR INTER FACE
TA-236	AUTOSEVOCOM	TC-10	TRI-TAC DATA ADAPTER (DØ)	CNCE	CONTROL AND STATUS INTER FACE
TA-312	COMMERCIAL	SB-3914		GRC 143	
TA-838	TTC-39	SB-3082		TD 204	
KY-3	TTC-38	H.F.		TD 754	
NBST	TTC-30	CV2907		LOOP GROUPS	
WECO 2500	TTC-28	CV2875			
AUTOVON TP	TTC-25	CV1919			
ANALOG DATA TERM	TTC-22	CV1918			
	TTC-7	TC-10			
	TTC-5	SB-3914			
	TTC-4	SB-3082			
	H.F.	SB-86			
	CV2907	SB-22			
	CV2875				

DATA TERMINAL EQUIPMENT (DEDICATED & AN/TTC-39 CIRCUIT SWITCH SWITCHED)

AN/TTC-39 MESSAGE SWITCH TRUNK

AUTODIN TRUNKS

AN/TTC-39 CIRCUIT SWITCH TRUNKS

ENGINEERING ORDERWIRE

ANALOG & DIGITAL DIAL ACCESS TO SWITCHED TERMINAL

INTERSHELTER CABLING INTERFACE

5. Multiplexing technique
6. Signal levels
7. Protocols
8. Physical length
9. Signaling and power considerations

3.3.2 Interface Characteristics

In spite of the numerous loop and trunk equipments served by the AN/TTC-39, there are a few generic classes into which all equipments may be divided, namely:

1. Battery mode (local or common)
2. Signaling mode (in-band or out-of-band)
3. Supervision mode (in-band or out-of-band)
4. Bandwidth (4 kHz or wide-band)

These terms historically have been applied to analog loop and trunk plants, but can be extended to apply to the digital world as well. The battery modes of the analog and digital domains are consistent and require no re-definition. The bandwidth of a 4 kHz analog device has as its equivalent the 16/32 kHz digital diphase data rate with its attendant bandwidth. In the case of analog equipment, in-band or out-of-band signaling and supervision refer to techniques whose frequencies pass through the normal voice bandwidth or not. In the case of digital equipment, the same terms refer to techniques whose information bits pass through the same physical channel or not. Common channel signalling may also be applied to analog trunk groups between two AN/TTC-39 switches.

Table 3-2 contains a re-listing of the analog and digital loop and trunk equipments in terms of the preceding generic classifications.

The two shelters that comprise each of the switches are interconnected by sets of cables. Functions performed via these cables include Control Processor Input/Output, miscellaneous Control/Status and Alarms and, in the case of the Circuit Switch only, the Loop Key Generator interface. The Control Processors for each switch are redundant for reliability purposes, and therefore require redundant interconnections to the other shelter that contains the peripheral equipment being served. Information transmitted via the cables consists of data bytes and address, request and command bits in digital

TABLE 3-2 LOOP/TRUNK FUNCTIONAL CLASSIFICATION

	ANALOG		DIGITAL	
	LOOPS	TRUNKS	LOOPS	TRUNKS
Local Battery In-band S/S 70-108 KHz Bandwidth	TA 341 TA 838 TA 720 NBST AUTOVON TP	AN/TTC-25, -30, -38, -39 CV 1918, 1919, 2875, 2907 AUTOVON (CONUS/OVERSEAS) SB 3614		
Local Battery In-band Signal Out-of-band Supv 70-108 KHz Bandwidth		Commercial PBX AUTOVON		
Common Battery In-band S/S In-band Supv			DSVT DNVT Diphase Modem	
Local Battery Out-of-band S/S				Digital Satellite TD 759, 204 AN/GRC-143 Msg Sw Trunks Ckt Sw Trunks Loop Ground MUX Remote Loop MUX

baseband form, all at asynchronous burst rates of approximately two megahertz. The miscellaneous Control/Status and Alarm cables contain signals that, for the most part, are unique to each switch, such as that related to particular hardware or devices. Common signals include Engineering Order Wire, intercom, analog and digital voice, teletypewriter, etc., and have transmission rates consistent with these terminal equipments. The Loop Key Generator cables interconnect the Time Division Switching Matrix in the Switching Shelter with encryption/decryption devices in the Control Shelter. Data transmitted over the cables consists of 16/32 kHz digital voice information on each of 64 channels. Figure 3-3 illustrates the intershelter cables presently employed in the AN/TTC-39 600-line switch configuration.

The classifications discussed thus far in sub-section 3.3 have been condensed and presented in Table 3-3 in summary form. These classifications and their attendant characteristics listed in Appendix E form the background for assuring that the selected fiber optic alternatives meet the AN/TTC-39 system performance requirements.

3.3.3 Characteristics of Alternatives

Using the preceding guidelines and system performance requirements, four fiber optic alternatives to existing analog loop techniques were selected. Two of these alternatives incorporate existing inventory equipment, while the other two require special-purpose interfacing hardware. The same approach was taken for all alternatives, namely, concentration of multiple subscribers into a single channel for subsequent transmission in serial form to and from the AN/TTC-39 switch.

The proposed equipment consists of TD-660 and TD-754 multiplexers that are capable of converting up to 24 four-wire voice channels into a single time-multiplexed PCM data stream. One alternative employs such equipment at both ends of the serial link, while the other complements this equipment at one end with switch-adapted special-purpose hardware at the other. The latter approach allows the advantages of compatible rack-mounted hardware to be compared with the equivalent field-survivable hardware. These two approaches are illustrated in Figure 3-4.

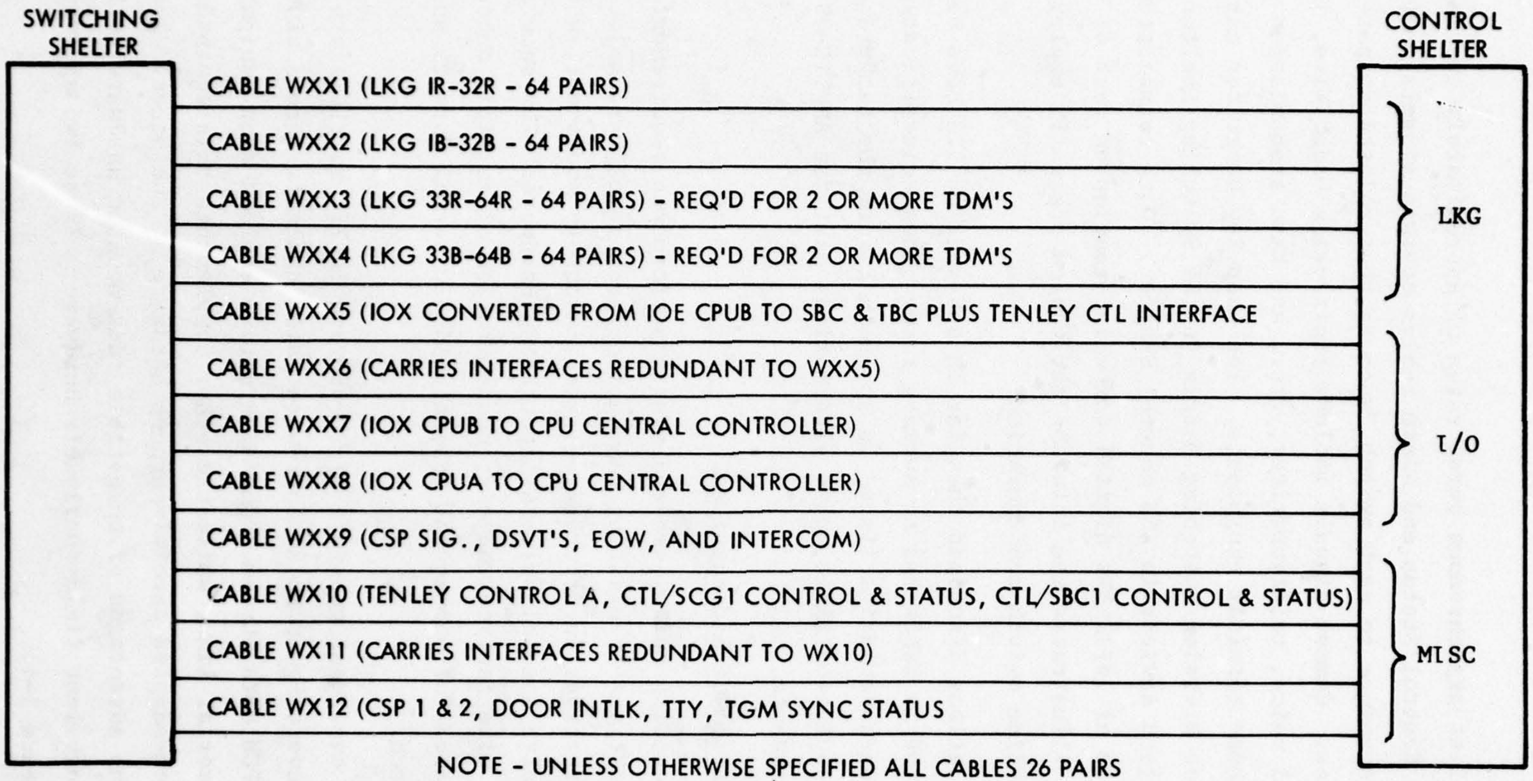


Figure 3-3. Inter-Shelter Cabling, Functional Assignment

TABLE 3-3. SUMMARY OF AN/TTC-39 INTERFACE CHARACTERISTICS

INTERFACE \ TYPE	CIRCUIT SWITCH	MESSAGE SWITCH
Analog Loops & Trunks	Local Battery, In-Band Signalling & Supervision Common Battery, In-Band Signalling Common Battery, Out-of-Band Signalling	Switched Trunks No Signalling
Digital Loops & Trunks	Common Battery (Loops), In-Band Signalling & Supervision Local Battery (Trunks), Out-of-Band Signalling & Supervision	Local Battery (Loops), Dedicated, In-Band Protocol Local Battery (Trunks), Switched, Common Channel Signalling
Intershelter	I/O Transfer Analog & Digital Voice Status (d-c) Red/Black	I/O Transfer Analog & Digital Voice Status (d-c)

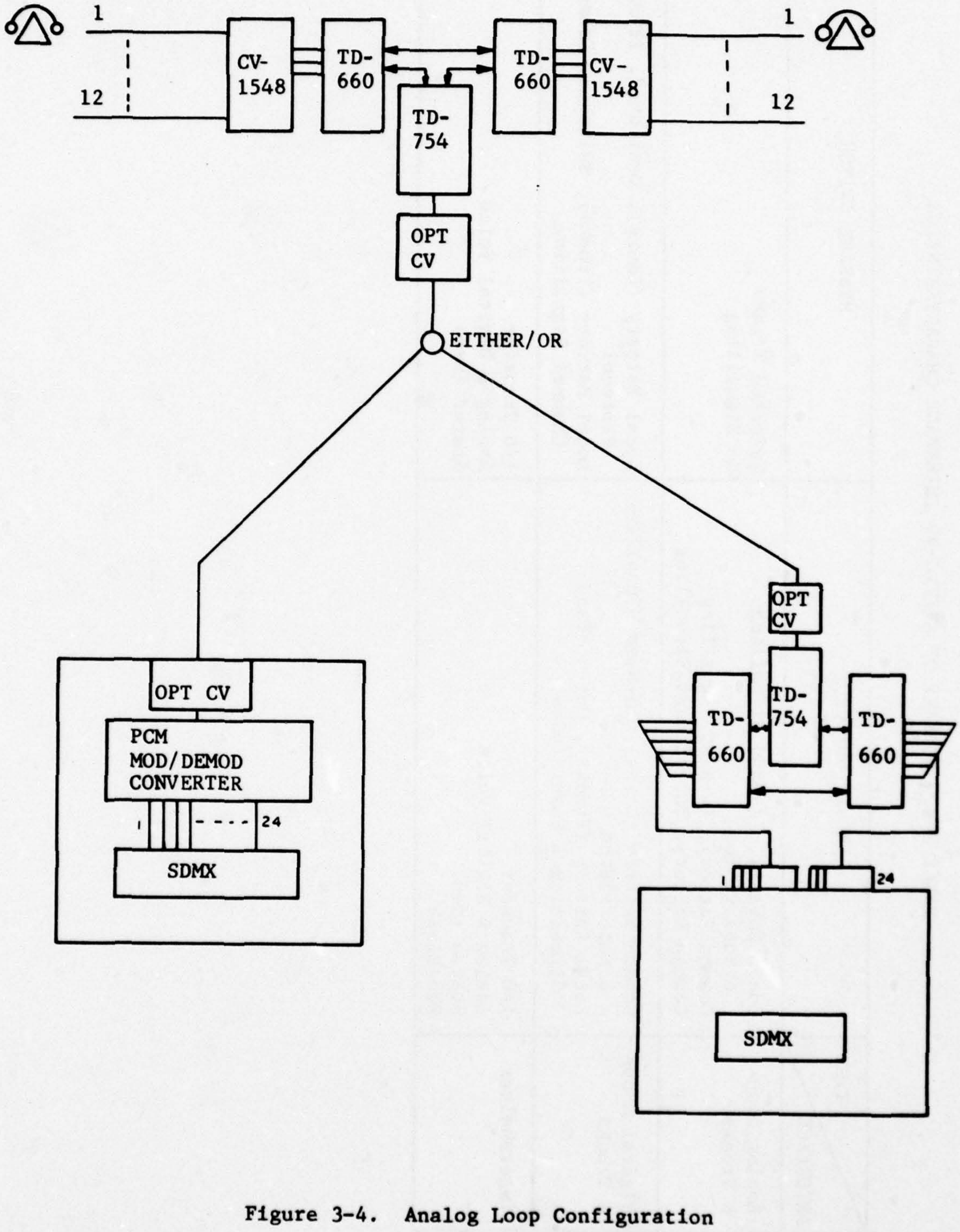


Figure 3-4. Analog Loop Configuration

The other two alternatives employ special-purpose hardware that concentrates subscribers at a remote location but in a form that is more directly compatible with the AN/TTC-39 switch. One approach concentrates subscribers using frequency-multiplexing techniques for entry into the AN/TTC-39 Space-Division Matrix (SDMX), while the other concentrates subscribers using time-multiplexing techniques for entry into the Time-Division Matrix (TDMX). The latter is directly compatible with the TDMX multiplex organization, while the former requires additional multiplexing equipment at the switch to separate the voice channels into the SDMX (single-channel) organizational requirements. These two approaches are illustrated in Figure 3-5.

Trunks are communication channels between switches; therefore, the concentration functions are automatically performed by the two switches at the ends of the trunk. In the case of the analog trunks, these channels are still in a space-division form. Therefore, the proposed fiber optic alternative includes a frequency-multiplexing function for reducing the number of individual channels and maximizing the fiber optic bandwidth capabilities. Figure 3-6 illustrates this alternative, which is similar to that shown in Figure 3-4.

Digital loops and trunks, on the other hand, lend themselves to fiber optics because of their signaling and supervision protocols. Digital trunks are already in a time-multiplexed form; thus, only the replacement of a trunk modem by an optical modem is required. Digital loops, on the other hand, require time-multiplexing, after which they can be treated in a manner exactly the same as that for digital trunks. Equipment for performing this time-multiplexing function, while not yet in current TRITAC inventory, has been developed and will undergo extensive field testing shortly. Therefore, for purposes of this study, it has been assumed that this Loop/Group Multiplex equipment will be available at the time when subsequent fiber optic techniques are introduced. Figures 3-7(a) and 3-7(b) illustrate the proposed alternatives for both digital loops and trunks.

The fiber optic alternatives discussed previously apply to the AN/TTC-39 Circuit Switch. The colocated Message Switch interfaces with the following equipments:

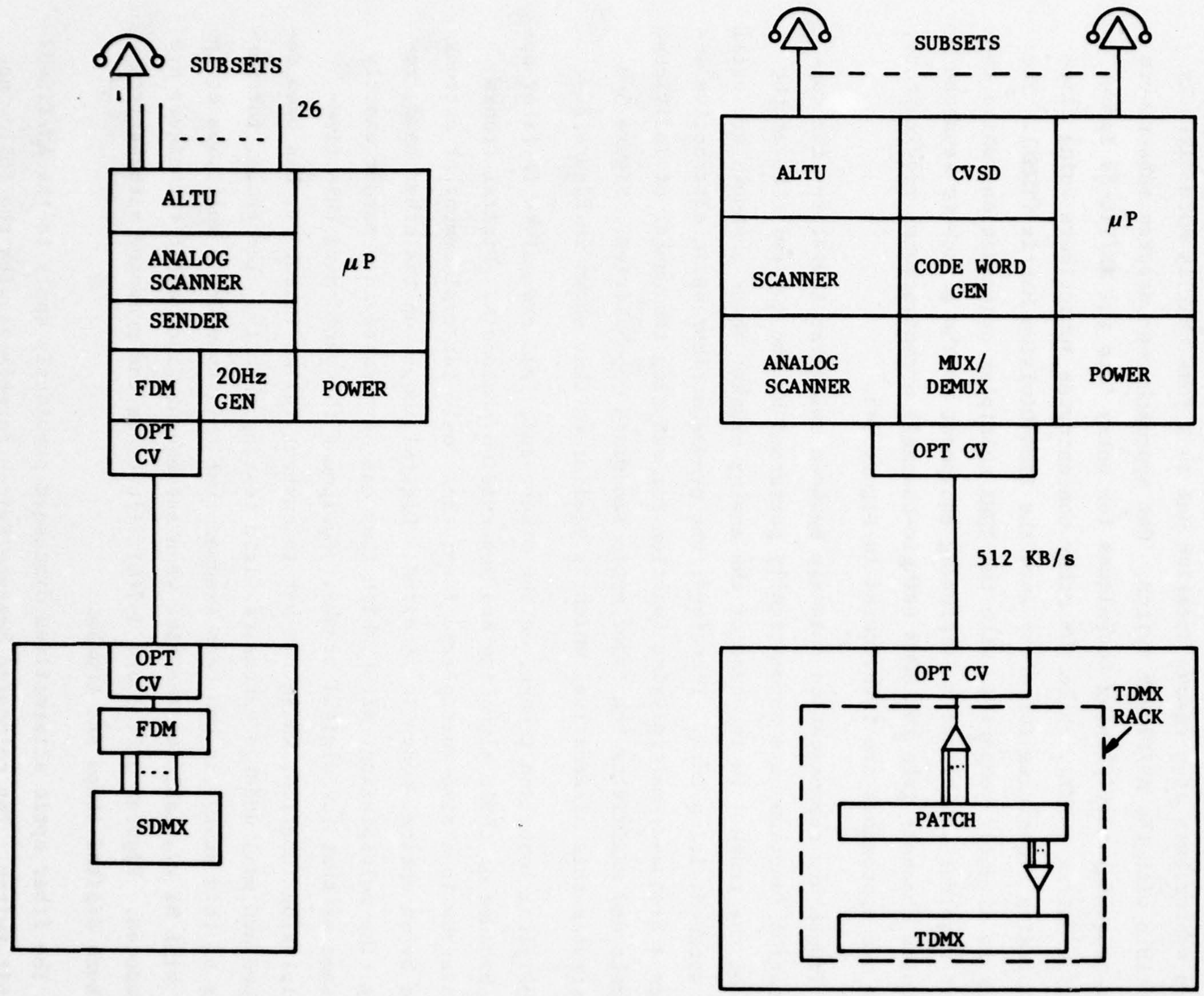


Figure 3-5. Analog Loops

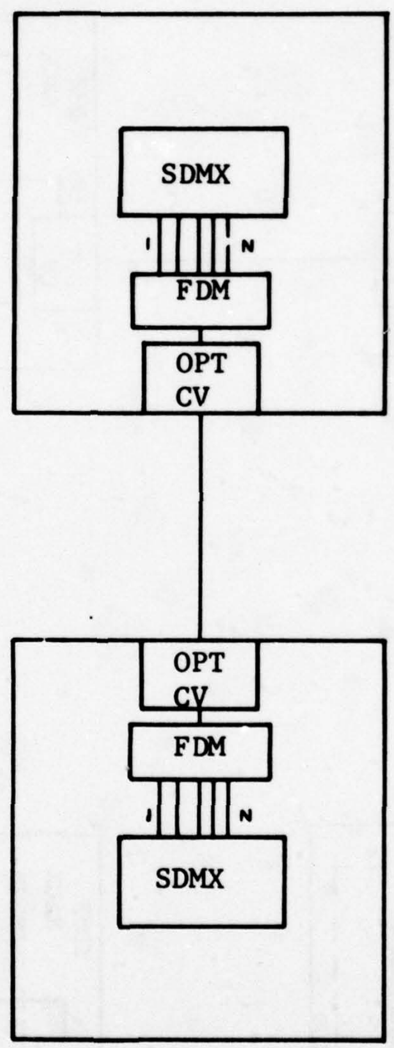


Figure 3-6. Analog Trunks

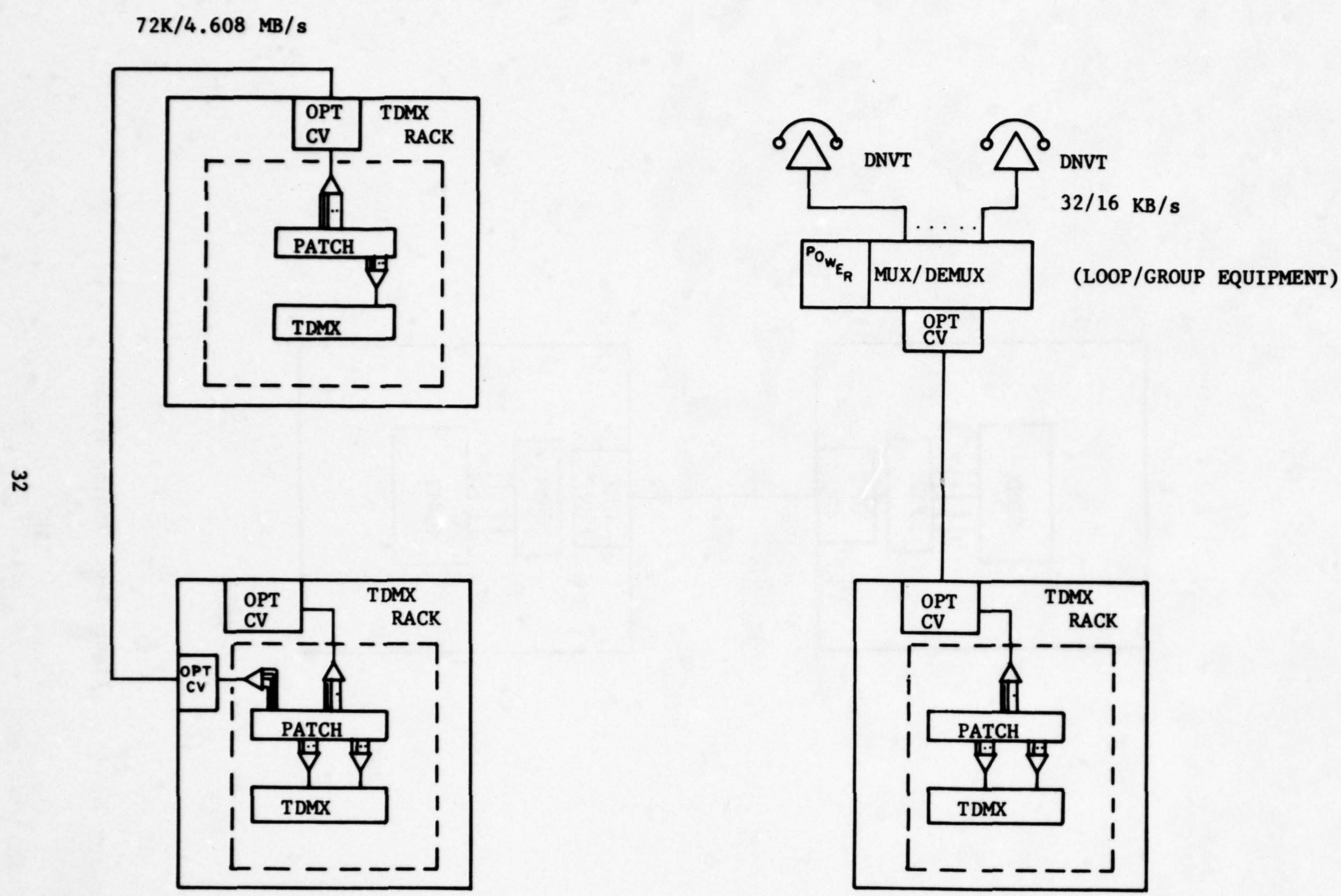


Figure 3-7. Digital Loops and Trunks

1. The Circuit Switch (analog and digital trunks)
2. Another Message Switch (dedicated trunks)
3. External terminal equipment

Each of these interfaces can be treated in a manner similar to those described for the various interfaces to the Circuit Switch.

The fiber optic alternative for inter-switch trunks consists of replacement of coaxial by optical fiber modems in the case of digital trunks and by optical modems plus FDM equipment in the case of analog trunks. Three alternatives have been selected for implementing the interconnection between two Message Switches. The first employs a line-for-line replacement utilizing fiber optic modems for each of the dedicated trunks. The second requires the addition of time-multiplexing equipment for concentrating the trunks into a single channel. The third incorporates existing TRITAC inventory equipment as an external time-multiplexer for performing the same multiplexing function. Each of these alternatives is illustrated in Figure 3-8.

Although there is a large variety of external terminal equipment that must interface with the Message Switch, there are a reasonably few fiber optic alternative techniques. Two of the proposed alternatives employ the line-for-line replacement using either a diphase or baseband compatible optical modem. The third incorporates an FSK compatible modem for use with devices such as teletypewriters. These alternatives are also illustrated in Figure 3-8.

The final areas for potential applications involve the interconnections between shelters of the respective switches. Each switch contains interconnections between the control processor in one shelter and the terminal equipment in the other. The proposed fiber optic alternative employs parallel-to-serial converters in each shelter so as to minimize the number of physical paths and reduce the size and weight of intershelter cabling. Each switch also contains interconnections of various control and status signals, intercoms, digital and analog voice communications and various interlock indicators. The proposed fiber optic alternative employs analog-to-digital converters and multiplexing equipment for reducing the multiple channels to a minimum for similarly reducing size and weight. The Circuit Switch contains the

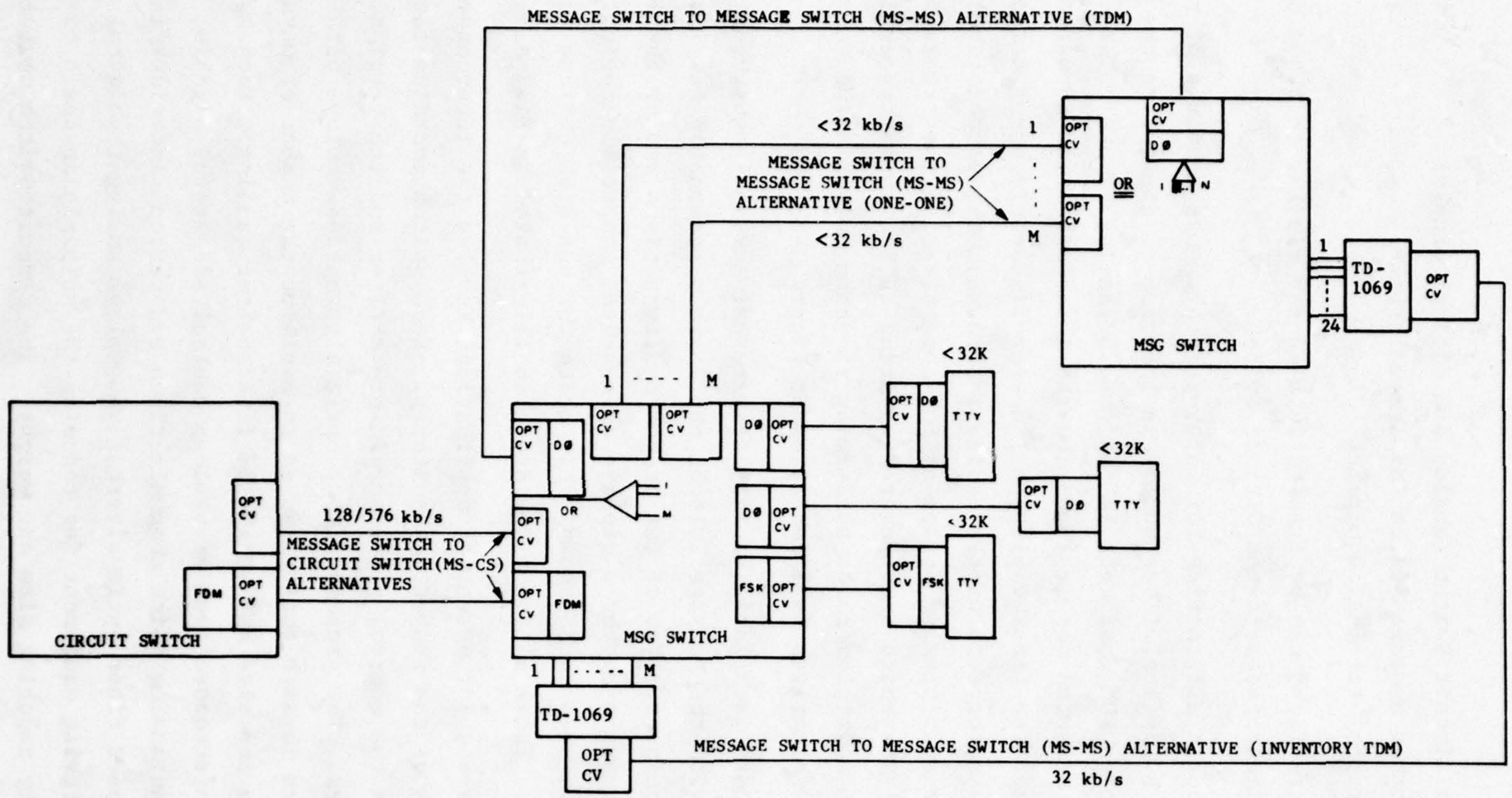


Figure 3-8. Message Switch Connectivity

unique Loop Key Generator interface that provides encryption services at the Control Shelter for digital subscribers terminated at the Switching Shelter. The proposed fiber optic alternative incorporates multiplexing equipment for concentrating the various channels in a single time-multiplexed channel, again to reduce size and weight over those of present conductors. In this latter case, however, only one terminal of the link, namely the Control Shelter, requires multiplexing equipment, since the TDMX at the Switching Shelter is already compatible with time-multiplex formats. The Loop Key Generator proposed alternative is illustrated in Figure 3-9; the Processor alternative is illustrated in Figure 3-10. Due to the various means for implementing the third interface, no specific illustration is shown.

3.4 DETERMINATION OF COSTS AND BENEFITS

Fiber optic alternatives become attractive if they provide improved performance at the same cost or similar performance at a reduced cost. In order to be aware of the costs and benefits attributable to the various proposed alternatives, a review of the elements contributing to each of these areas was made, the results of which appear in the following sub-sections.

3.4.1 Costs

For purposes of this study, costs of alternatives were determined as either real or relative. Real costs are those arising from dollar valuations of present and proposed concepts that allow determination of actual savings. Relative costs are those not directly related to actual dollar costs but nevertheless reflect judgmental estimates as to which of two alternatives is the more expensive to implement.

All of the proposed alternatives involve replacement of existing conductors by optical fibers. The present and projected costs of fibers vs twisted-pair and coaxial transmission lines have been well discussed in the literature, and real costs are readily available. These costs are listed in Table 3-4, together with other parameters of interest that were conveniently extracted from the same sources. Where known distances can be determined, as in the cases of inter-shelter cables, direct cost trade-off requires only a calculation. In other cases, cost estimates are only as good as estimates of the distances involved.

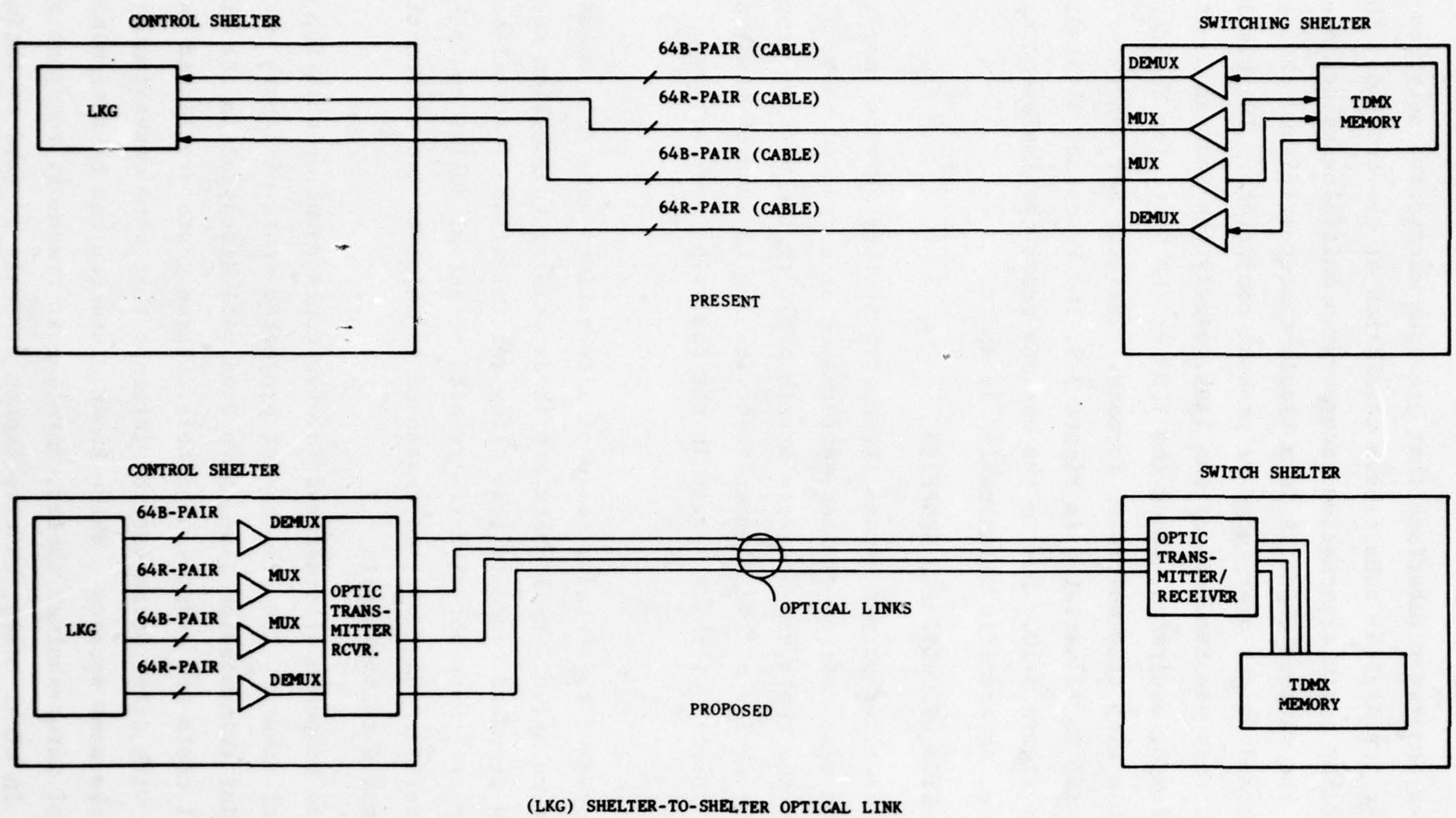


Figure 3-9. Proposed Loop Key Generator Connectivity

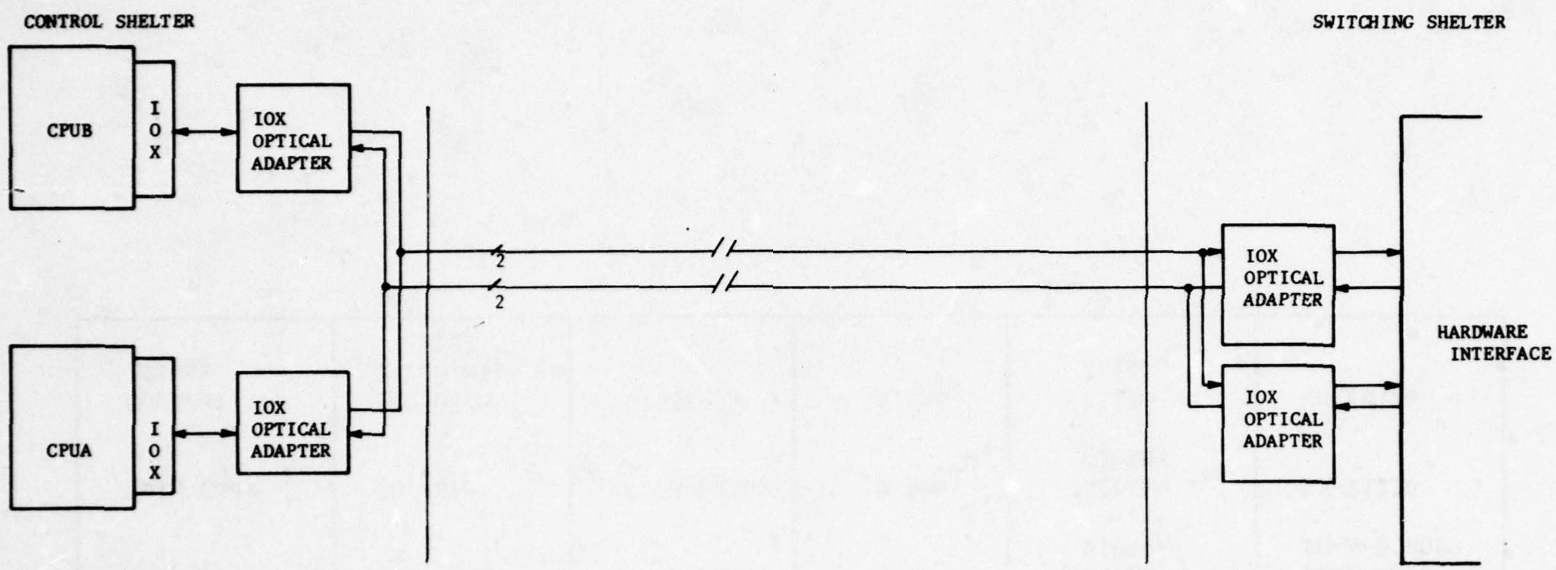


Figure 3-10. Proposed Processor I/O Connectivity

TABLE 3-4 CHARACTERISTICS OF TRANSMISSION MEDIA

TYPE	COST	WEIGHT	DIAMETER	ATTENUATION	BASIS
26-pair STP	\$6.70/m	1.8kg/m	42mm	3dB/km @10kHz	CX-4566
64-pair STP	\$6.00/m	1.7kg/m	40mm	3dB/km @10kHz	ECOM Spec SM-A-838029
Twin Coax	\$0.88/m	0.135kg/m	9.5mm	25dB/km @10kHz	CX-11230
Optical Fiber	\$10.00/m (\$1.00/min 1985)	0.08kg/m	5.5mm	<15dBm flat	Corguide

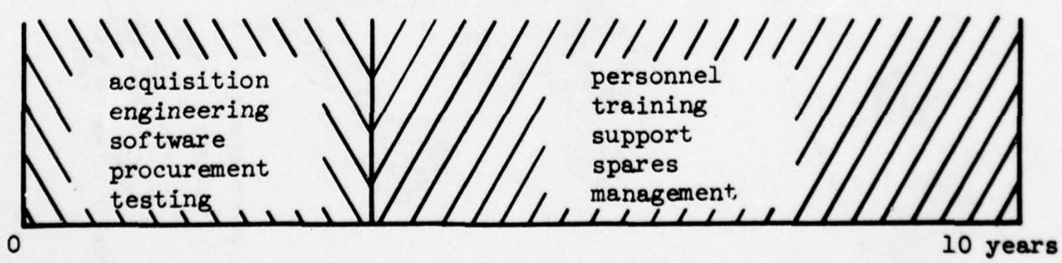
Although the optical transmitter/receiver costs can be reasonably estimated, these components perform only a few of the many modem functions, such as baseband conversion, clock recovery, supply of line power, engineering order wire and line terminal protection. Because of these other functions, the cost of an optical modem was estimated to be the same as that for the replaced modem.

Where alternatives incorporated multiplexing equipment, digital multplexing was estimated to be less costly than analog multiplexing equipment performing the same function or serving the same number of channels. This arises principally because of the decreasing costs of digital LSI/MSI components and the still-high costs of analog filters.

Cost comparisons between special-purpose hardware and off-the-shelf inventory equipment were made on a relative basis. The trade-off generally favored new equipment designed into existing sub-systems because many packaging and electrical/mechanical environments were attenuated by existing features, whereas for the inventory equipment such problems were solved for each and every instance on a stand-alone basis. The other advantages obtained through the use of inventory equipment were not ignored, however.

The preceding costs discussed are acquisition costs, and form a small part of the overall life cycle cost of the AN/TTC-39 system. This total consists of 47 Message Switches plus 93 600-line and 152 300-line Circuit Switches transported in 432 shelters and associated support pallets and equipment typical to those illustrated in Figure 3-11.

This system has a projected lifetime of ten years, consisting of development and operation/maintenance phases as illustrated below:



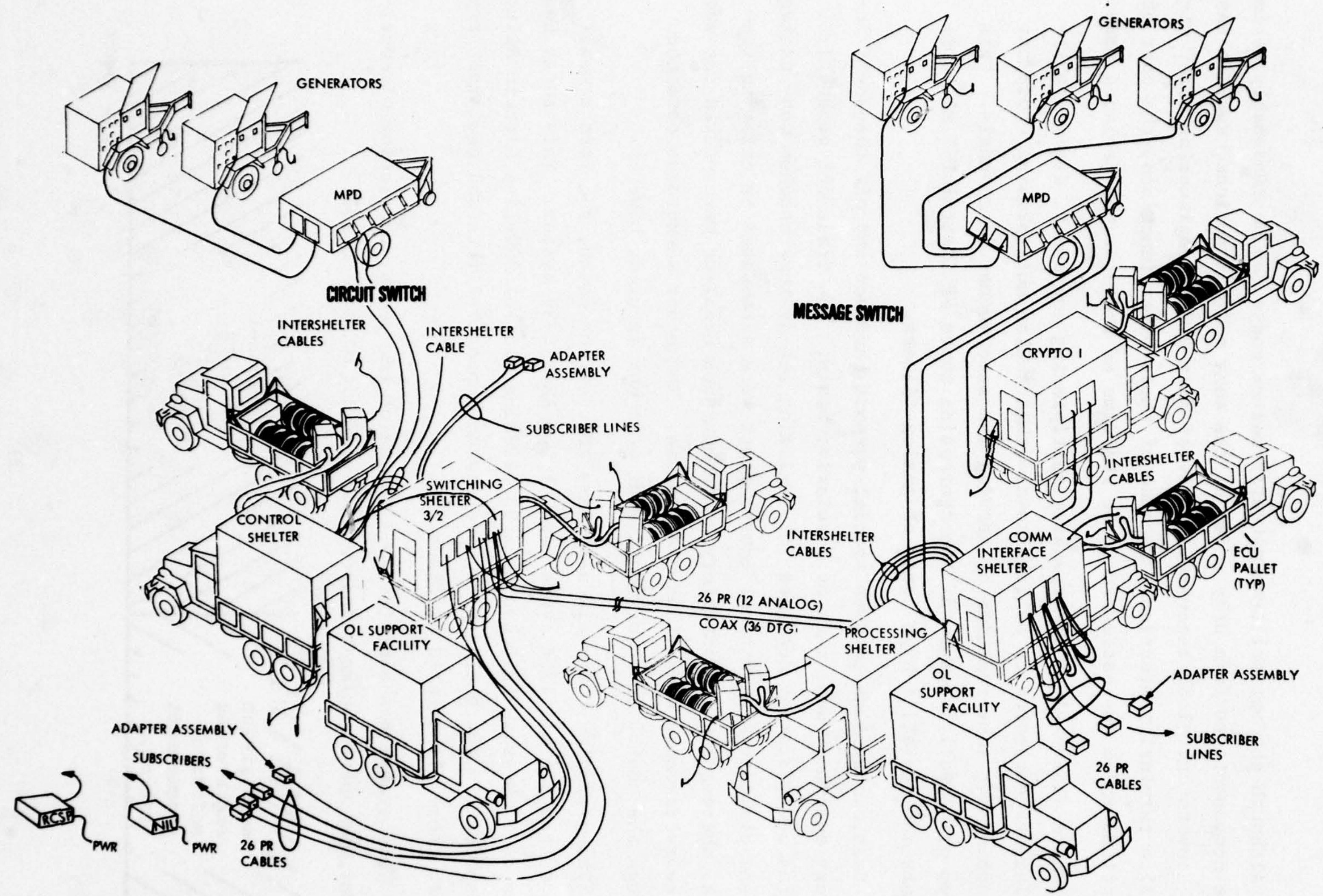


Figure 3-11. Typical AN/TTC-39 Nodal Deployment

Part of the O&M cost is attributable to shipments of deliverable equipments from Needham, Mass. to Forts Monmouth and Huachuca, and subsequent relocations at fixed intervals to various locations throughout CONUS. A breakdown of life cycle costs is illustrated in the cost-by-phase and cost-by-element charts of Figure 3-12. The Design-to-Unit-Production costs, incurred during the initial phase, plus the transportation cost, incurred during the second phase, constitute the principal costs of interest to this study. The DTUPC costs were estimated on a relative basis as discussed previously. The transportation costs are primarily a function of the differences in the transported weight for the various alternatives as compared to the present techniques. These costs are significant, because the total transportation costs for the entire system over the ten-year life amount to $7 million. A savings of 10% in cable weight alone can result in a potential savings of $187,000. The present life cycle model used for predicting such costs indicates that the average cost/pound exceeds $0.08 over the life cycle. For the life cycle parameters used, these become real costs for evaluating alternatives.

3.4.2 Benefits

Neglecting the cost factor for the moment, benefits can be realized as improvements in performance or as reductions in logistical requirements. In order to allow as much variability as possible in the subsequent evaluation of the various alternatives, these two areas were further sub-divided into fifteen categories generally used by analysts for performing system trade-off studies. Each category was defined in terms of its positive attribute; that is, the description of that constituting improved performance or reduced logistical requirements. These categories and the accompanying definitions are as follows:

<u>EMP Invulnerability</u>: The ability to reduce unwanted EMP response or delete protective devices

<u>EMI Insensitivity</u>: The ability to decrease unwanted energy coupling or radiation

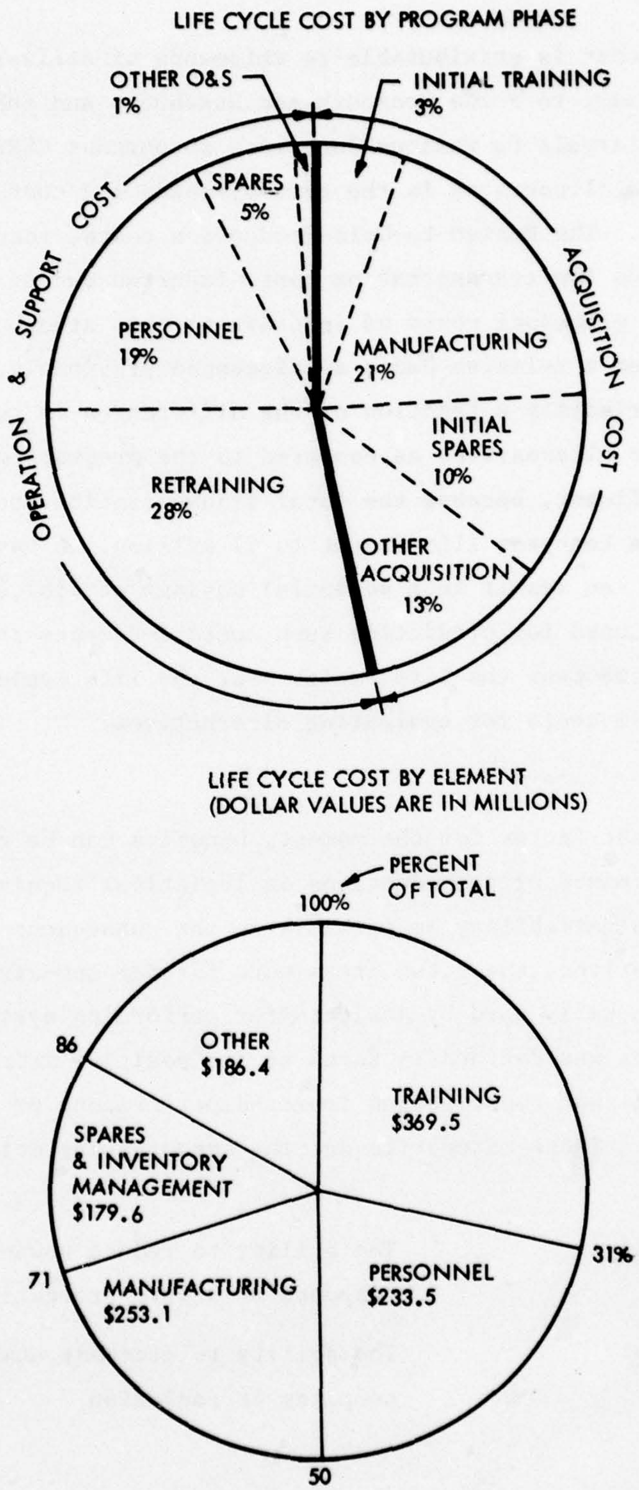


Figure 3-12. Life Cycle Costs

EM Compatibility:	The ability to operate with colocated equipment on a non-interfering basis
Cross-talk Immunity:	The ability to reduce circuitry and inter- and extra-shelter conductors
Physical Size:	The ability to decrease cable size, number of support pallets and trucks, shelter wall space and number of protective devices
Physical Weight:	Same as above, plus ability to decrease transportation costs
Power Requirements:	The ability to decrease overall power budget and need for external power sources
Signaling/Supervision Rqmts.:	The ability to decrease converter types and simplify protocols
Orderwire Requirements:	The ability to facilitate incorporation of various orderwire techniques
Reliability:	The ability to reduce the number of parts and to improve the MTTF of the system
Maintainability:	The ability to reduce the number of spares and level of skill required for maintenance
Modularity:	The ability to satisfy common application requirements and facilitate analog-to-digital system conversion
Operational Compatibility:	The ability to interface with other TRITAC equipment and current inventory equipment

Setup-Teardown: The ability to reduce the time needed to perform functions

Security: The ability to provide protection of secure data lines and containment of secure areas

These categories were used as focal points to insure that all potentially favorable attributes were examined and given proper value in the evaluation of the various fiber optic alternatives.

3.5 RANKING OF ALTERNATIVES

This section describes the approach taken for ordering the list of previously discussed fiber optic alternatives in terms of desirability for performance of a subsequent feasibility development. This approach consisted of the following steps:

1. Evaluation of each alternative in terms of categories generally used to measure performance;
2. Assignment of a weighting factor indicating the relative value of each category to an alternative;
3. Ordering of alternatives according to the scores resulting from the weighted totals of the above steps.

3.5.1 Evaluation Categories

The categories used for evaluation consist of the cost and performance categories discussed separately in the previous sub-section. The combined list is shown in Table 3-5.

During the course of the study, several changes were made in this list. The EMP, EMC and EMI categories were combined because all are measures of the effects of electromagnetic fields upon conductors. Furthermore, the specific engineering orderwire requirement has not yet been confirmed; therefore, it was deleted from the list. Lastly, operational compatibility was established as a criteria for the selection of alternatives; therefore, it also was deleted from the list.

TABLE 3-5 EVALUATION CATEGORIES

CLASS	RANGE	CATEGORY
Basic	1 - 5	Size
		Weight
		Power
		Cost
Specification	1 - 4	EMP/EMC/EMI
		Crosstalk
		Signaling/Supervision
		Security
Support	1 - 3	Reliability
		Maintainability
		Modularity
		Set-Up/Teardown

Each alternative was evaluated in terms of these categories and scored in the range of +5 to -5, where a positive score represented improvement in performance or decrease in cost and a negative score represented the opposite. The numerical score represented the degree of improvement or, in the negative case, the degree of degradation.

As an example, a score of +5 was given for the EMP/EMC/EMI category in the case of every alternative, because the fiber optic technique obviated the electromagnetically related problem area entirely. The physical/weight scores were generally positive, and the magnitude was determined largely by the amount of copper conductors replaced. Setup/teardown time received positive scores for similar reasons, while power requirements was generally scored negative reflecting the difficulty of providing a dc current path over optical fibers. Security and cross-talk immunity received positive scores because of the high isolation capability of optical fibers. However, reliability and maintainability received negative scores because of the novelty of the current technology, and the increase in skill levels required. The costs were scored on the basis of both real values, as in the case of the fibers, and relative values, as in the case of the associated circuitry.

3.5.2 Category Weighting

Table 3-5 also reflects the weighting factors used to indicate the relative importance of the various categories to each fiber optic alternative. This technique precludes a major improvement in a relatively unimportant category from being equated to a major improvement in a more important category. Weights ranging from 1-5 were assigned to the Basic class of categories, indicating their fundamental importance to all alternatives. Weights ranging from 1-4 were assigned to the Specification class, indicating their lesser importance. Weights ranging from 1-3 were assigned to the Support class, indicating that these categories are of significance only after the preceding category requirements have been satisfied.

For example, higher weights were given to the Security category for the intershelter link alternatives because of the need for maintaining physical and electronic security in the switching area. Size and weight categories

received higher weighting factors in loop alternatives rather than trunk alternatives, because of the greater impact of savings over the more multitudinous loops. Moreover, cost impact is greater for loop rather than trunk alternatives for the same reasons, and a higher weight was assigned accordingly. Reliability and maintainability were weighted higher for alternatives containing concentrations of users, such as intershelter links and trunks, and lower for single-user cases such as loops, because of the built-in redundancy of the latter. Power requirements were weighted lower for those alternatives having abundant resources, such as shelters, rather than widely distributed users such as loops.

3.5.3 Evaluation Mechanics

The determination of evaluation scores and assignment of weights to the list of fiber optic alternatives are separable operations. The weighting operation is a system-oriented function that can be performed without knowledge of the number and type of the various alternatives. On the other hand, evaluation scoring is a design-oriented function that can best be performed by comparing the various alternatives in each category. This independence in performing the two operations minimizes the subjective nature of the analysis and maximizes objectivity by combining the results of independent judgments.

This independence suggests the use of a matrix organization for determining the results of the evaluation analysis, as illustrated in Table 3-6. As indicated, the operations of weighting and scoring are performed first (in either order) followed by the operations of totaling and normalizing, the latter steps being merely the summing of the weighted scores. The desired ranking can be obtained by listing the normalized weighted scores in descending order.

3.5.4 Results

Table 3-7 is a matrix of the results obtained by following the previously described procedures. The selected fiber optic alternatives are listed along the top row and the categories are listed along the left-hand column. Each intersection contains a weighting factor and a score. The

TABLE 3-6 EVALUATION APPROACH

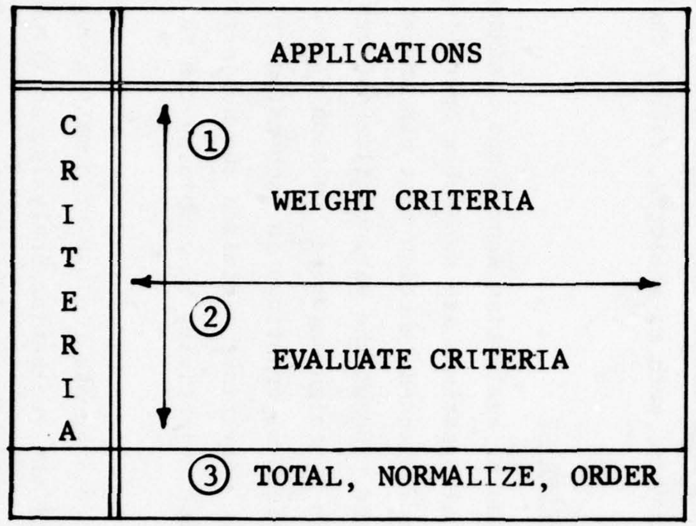


TABLE 3-7 SUMMARY EVALUATION MATRIX

	INTERSHELTER						ANALOG TRUNKS		DIGITAL TRUNKS		MS-CS		MS-MS						DIGITAL LOOPS				ANALOG LOOPS					
	LKG		I/O BUS		OTHER								ONE-ONE		TDM		INVENTORY TDM		ONE-ONE		MUX		PCM		TDM		FDM	
EMP/EMC/EMI	3	+5	3	+5	3	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5	4	+5
Cross Talk Immunity	2	+1	2	0	2	+3	4	+4	1	0	3	+2	1	+1	1	+5	1	+3	1	+1	1	+5	4	+5	4	+5	4	+2
Physical Size	2	+3	2	+3	2	+1	4	+3	1	+1	3	+1	5	-1	5	+1	5	-3	5	+1	5	+3	5	+1	5	+3	5	+1
Weight	2	+3	2	+3	2	+1	4	+3	1	+1	3	+1	5	-1	5	+1	5	-3	5	+1	5	+3	5	+1	5	+3	5	+1
Power Requirements	1	-1	1	-1	1	0	1	-3	1	0	1	-1	1	0	1	-3	1	-5	5	0	5	-1	4	-5	4	-5	4	-5
Signaling/Supervision	1	0	1	-3	1	-3	3	-1	2	0	2	0	2	0	2	-1	2	0	2	0	2	-1	4	+1	4	+3	4	+1
Reliability	3	-5	3	-3	3	-3	2	-1	2	+5	2	+1	1	+3	1	+1	1	-5	1	+3	1	+1	1	-5	1	+1	1	-5
Maintainability	3	-3	3	-3	3	-3	2	-5	2	+3	2	-1	1	0	1	0	1	-3	1	-1	1	+1	1	-5	1	+3	1	-5
Modularity	1	0	1	-5	1	-5	2	-3	2	0	2	-1	3	+3	3	+3	3	-3	3	+3	3	+3	3	-3	3	+3	3	-3
Setup/Teardown	1	+3	1	+3	1	+3	2	+3	2	+1	2	+1	3	0	3	+3	3	+1	3	0	3	+3	3	+3	3	+3	3	+3
Security	4	+5	4	+5	4	+5	2	+5	3	+3	3	+4	2	+3	2	+5	2	+4	2	+3	2	+5	1	+5	1	+5	1	+5
Acquisition Cost	1	+3	1	+2	1	+1	3	-2	3	+3	3	-3	4	+1	4	+1	4	-1	4	-1	4	-2	4	-3	5	-2	5	-3
Oper. & Maint. Cost	1	+3	1	+2	1	+1	3	-2	3	+3	3	-3	4	+1	4	+1	4	-1	4	-1	4	-2	4	-3	5	-2	5	-3
	+29/120		+23/120		+22/120		+46/165		+58/120		+34/155		+33/160		+63/160		-22/160		+44/180		+70/180		+17/195		+79/200		+2/200	
TOTALS	0.24		0.19		0.18		0.28		0.48		0.22		0.20		0.39		-0.14		0.24		0.39		0.09		0.04		0.01	

Legend: MS-CS — Message Switch to Cricuit Switch Link
MS-MS — Message Switch to Message Switch Link
One-One — Direct Replacement of Wire Path by Fiber Path
TDM — Alternative Using Time Division Multiplex (TDM) Equipment
Inventory TDM — Alternative Using Inventory TDM Equipment

sums of products of weights and scores are totaled for each alternative, and the results are normalized to the range of 0-1.

The left-hand side of Table 3-8 contains the ranked listed of the results of the evaluation. In general, two factors were found to be significant to the specific order:

1. Higher scores were given for the combination of digital formats and multiplexing techniques because of compatibility with the AN/TTC-39 switch and future TRITAC goals.
2. Higher scores were given for alternatives providing improvement or cost saving in loop rather than trunk alternatives.

The right-hand side of Table 3-8 contains the ranked list of results in terms of the functions shown. In each functional case, higher scores were given for alternatives using multiplexing techniques.

This summary of results was presented to ECOM for their guidance in selecting a desirable fiber optic application for further feasibility development. The analog loop alternative was recommended because of its score and the knowledge that ECOM is already pursuing the highest-scoring digital trunk alternative.

3.5.5 Selection of Application for Further Study

Following presentations of the preceding results to both ECOM and TRITAC, GTE Sylvania has been directed by ECOM to perform the detailed study of the intershelter alternatives, considering the three alternatives as a single application. The prime reason for this selection is attributable to the powering problem associated with the analog loop plant. The results of this detailed study will form the basis of a performance requirements definition for the subsequent feasibility development.

TABLE 3-8 LIST OF RANKED-ORDERED APPLICATIONS

RANKING OF APPLICATIONS	RANKING OF APPLICATIONS BY FUNCTION	
1. Digital Trunks	INTERSHLETER	
2. Analog Loops (TDM)		LKG (Serial)
3. Digital Loops (MUX)		I/O (Bus)
4. MS - MS (MUX)		Other (Non/Critical)
5. Analog Trunks (FDM)	DIGITAL	
6. Intershelter (LKG)		Trunks
7. Digital Loops		Loops (MUX)
8. MS - CS		MS - MS (MUX)
9. MS - MS		Loops
10. Intershelter (I/O)		MS - CS (FDM)
11. Intershelter Other (MUX)		MS - MS
12. Analog Loops (PCM)		MS - MS (Inventory TDM)
13. Analog Loops (FDM)	ANALOG	
14. MS - MS (Inventory TDM)		Loops (TDM)
		Trunks (FDM)
		Loops (PCM)
		Loops (FDM)

SECTION 4

DETAILED DESCRIPTION OF INTERSHELTER FIBER OPTIC LINKS

This section contains the design guidelines for implementing the selected fiber optic application, namely, the intershelter links. The following topic areas are addressed:

1. Current interconnection
2. Fiber optic interconnection
3. Physical interfaces
4. Electrical interfaces
5. Functional requirements

The AN/TTC-39 Circuit Switch currently incorporates special double-shielded twisted-pair cable sets for interconnecting the 600-line Switching and Control Shelters. The types of signals transmitted from shelter to shelter can be classified into three functional areas, namely:

a. Loop Key Generator
b. Processor Input/Output
c. Control and Status

Table 4-1 illustrates the functional assignment of the intershelter cabling sets, and indicates the present cabling number plan and signal connectivity.

In general, fiber optics have been employed to replace the existing cable sets and minimize existing hardware. For the purposes of feasibility demonstration, redundant channels have not been recommended for implementation. The electrical interfaces for the selected channels have been described in terms of input/output voltages, terminating impedances, rise/fall times; the functional requirements created by the new interfaces have been described.

4.1 LOOP KEY GENERATOR INTERFACE

4.1.1 Current Interconnection

The AN/TTC-39 contains a number of TENLEY loop key generators (LKGs) to provide the Circuit Switch with encryption/decryption services for secure subscribers. These LKGs are pooled as common equipment in the Control Shelter because of the multiplicity of key variables available to each subscriber.

TABLE 4-1 CIRCUIT SWITCH INTERSHELTER CABLE SET FUNCTIONAL SIGNAL INTERFACE

LKG Interface	Cable WXX1	COMSEC Rack LKG
	Cable WXX2	COMSEC Rack LKG
	Cable WXX3	COMSEC Rack LKG
	Cable WXX4	COMSEC Rack LKG
Processor I/O Interface	Cable WXX5	10X Converted from IOE, TENLEY Controllers
	Cable WXX6	Redundant to WXX5
	Cable WXX7	Central Processor Unit 2 IOX
	Cable WXX8	Central Processor Unit 1 IOX
Control & Status Interface	Cable WXX9	Call Service Position Talking Port, Encrypted and Non-Encrypted Digital Secure Voice Terminals, Engineering Order Wire Extensions, and Intercom
	Cable WX10	TENLEY Control A, Signal Buffer Controller and Switching Control Group Interface to Control Transfer Logic
	Cable WX11	Redundant to WX10
	Cable WX12	Call Service Position Signaling Ports Door Interlock Teletypewriter TGM Sync Status Prime Power Interlock Sum DC Power Interlock Overtemp Interlock

The intershelter wiring allows the LKGs to be connected to the Time Division Switching Matrix (TDMX) in the Switching Shelter, where they appear as full-duplex ports. Figure 4-1 illustrates two such secure subscribers; subscriber #1, using encryption key A, is in communication with subscriber #2, who is using encryption key B. The LKGs provide the encryption/decryption functions necessary to allow such communication. The information traversing these devices is thus both encrypted or Black and decrypted or Red data.

A total of sixty-four LKGs is necessary to meet secure traffic requirements; therefore, four 64-pair cables (WXX1 through WXX4) are needed for the intershelter interconnection of these signals. The present signal interconnectivity is indicated by heavy lines on the right-hand side of the Circuit Switch block diagram shown in Figure 4-2. This diagram illustrates the connectivity from the LKGs (in the HGF-82 rack) via the intershelter wiring to the Line Driver Interface, which converts the LKG bipolar signals to and from the switch TTL standard form. From there, the LKG signals are wired to the switch mux/demux equipment for direct access to the TDMX. Not shown are the Signal Entry Panels (SEPs) of the respective shelters whose connectors mate with the intershelter cables.

4.1.2 Fiber Optic Interconnectivity

Significant system benefits can be obtained by replacing the four 64-pair cables with one or more optical fibers and suitable multiplexing equipment.

One obvious alternative is the use of a transparent link interconnecting the interfaces just described. A typical implementation of such a link is illustrated in Figure 4-3.

This implementation requires two 1 x 64 multiplexers, two optical fibers and two receiver/transmitter pairs or modems for each (Red and Black) link. Furthermore, a means of synchronization is needed to maintain physical reference for each of the 64 LKG channels.

However, it should be noted that the multiplexed serial data stream is already in a form that is compatible with the serially-organized TDMX. By treating this data stream as a digital transmission group, half of the components in Figure 4-3 can be eliminated.

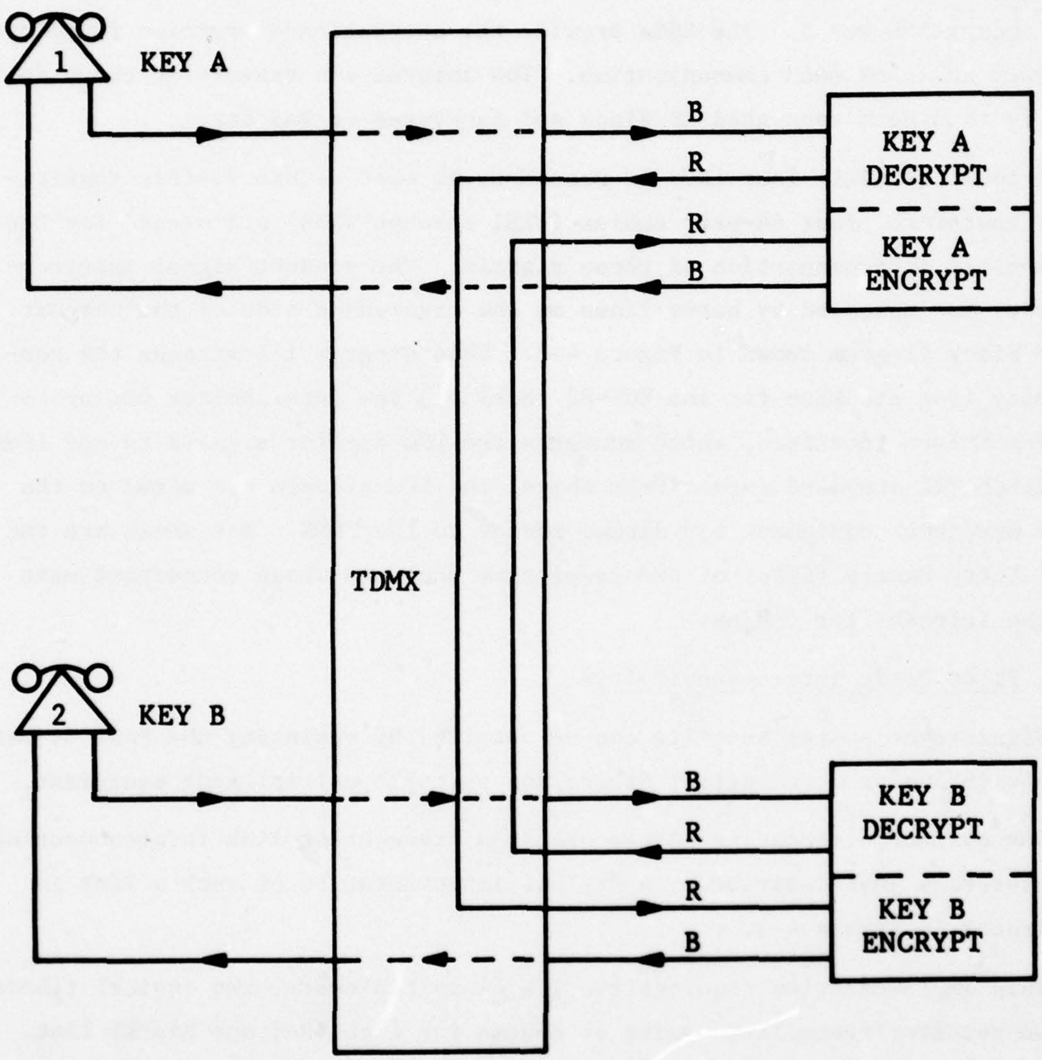
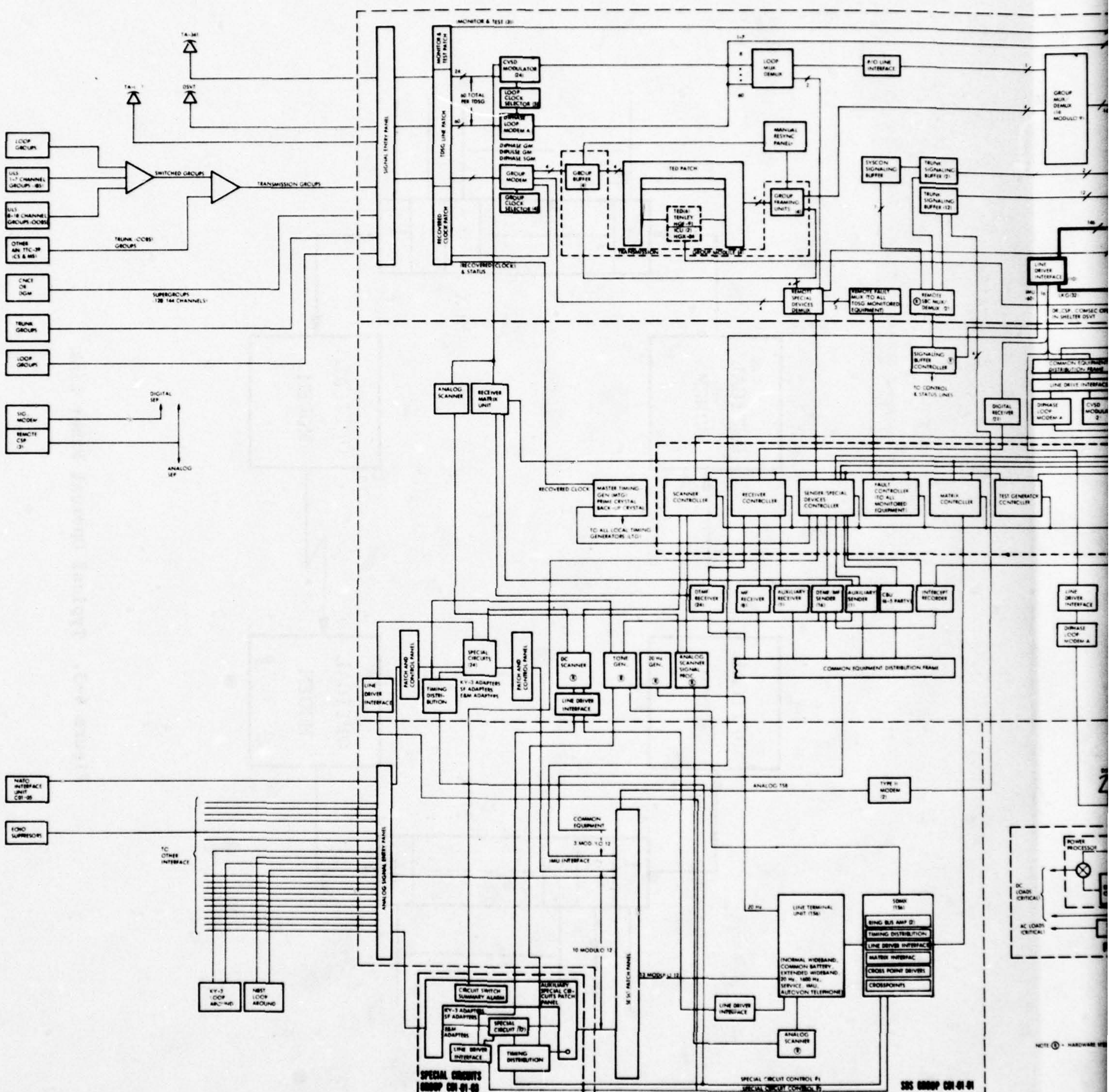


Figure 4-1. Secure Termination Connectivity



LOOP GROUPS
ULS 1-7 CHANNEL GROUPS (BS)
ULS 8-18 CHANNEL GROUPS (OCBS)
OTHER AN/TTC-39 (CS & MS)
CNCE OR DGM
TRUNK GROUPS
LOOP GROUPS
SWITCHED GROUPS
TRANSMISSION GROUPS
TRUNK (OCBS) GROUPS
SUPERGROUPS (128 144 CHANNELS)
SIG MODEM
REMOTE CSP (3)
DIGITAL SEP
ANALOG SEP
NATO INTERFACE UNIT C01-05
ECHO SUPPRESORS
TO OTHER INTERFACE
KY-3 LOOP AROUND
NBST LOOP AROUND
MONITOR & TEST (3)
SIGNAL ENTRY PANEL
MONITOR & TEST PATCH
TDSG LINE PATCH
RECOVERED CLOCK PATCH
CVSD MODULATOR (24)
LOOP CLOCK SELECTOR
DIPHASE LOOP MODEM A
DIPHASE GM
GROUP MODEM
GROUP CLOCK SELECTOR
60 TOTAL PER TDSG
GROUP BUFFER
TED PATCH
GROUP FRAMING UNITS
MANUAL RESYNC PANEL
LOOP MUX DEMUX
P/O LINE INTERFACE
GROUP MUX/DEMUX
SYSCON SIGNALING BUFFER
TRUNK SIGNALING BUFFER (2)
TRUNK SIGNALING BUFFER (12)
LINE DRIVER INTERFACE
RECOVERED CLOCK & STATUS
REMOTE SPECIAL DEVICES DEMUX
REMOTE FAULT MUX TO ALL TDSG MONITORED EQUIPMENT
REMOTE SBC MUX/DEMUX (2)
SIGNALING BUFFER CONTROLLER
TO CONTROL & STATUS LINES
DIGITAL RECEIVER (2)
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVE INTERFACE
DIPHASE LOOP MODEM A
CVSD MODULATOR
ANALOG SCANNER
RECEIVER MATRIX UNIT
RECOVERED CLOCK
MASTER TIMING GEN (MTG) PRIME CRYSTAL BACK-UP CRYSTAL
TO ALL LOCAL TIMING GENERATORS (LTG)
SCANNER CONTROLLER
RECEIVER CONTROLLER
SENDER/SPECIAL DEVICES CONTROLLER
FAULT CONTROLLER (TO ALL MONITORED EQUIPMENT)
MATRIX CONTROLLER
TEST GENERATOR CONTROLLER
DTMF RECEIVER (24)
MF RECEIVER
AUXILIARY RECEIVER
DTMF MF SENDER
AUXILIARY SENDER
CBU
INTERCEPT RECORDER
LINE DRIVER INTERFACE
DIPHASE LOOP MODEM A
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVER INTERFACE
PATCH AND CONTROL PANEL
TIMING DISTRIBUTION
SPECIAL CIRCUITS (24)
KY-3 ADAPTERS SF ADAPTERS E&M ADAPTERS
DC SCANNER
TONE GEN
20 Hz GEN
ANALOG SCANNER SIGNAL PROC
LINE DRIVER INTERFACE
ANALOG TSB
TYPE II MODEM (2)
ANALOG SIGNAL ENTRY PANEL
COMMON EQUIPMENT
IMU INTERFACE
10 MODULO 12
SE/SC PATCH PANEL
12 MODULO 12
LINE TERMINAL UNIT (TSB)
(NORMAL WIDEBAND, COMMON BATTERY, EXTENDED WIDEBAND, 20 Hz, 1600 Hz, SERVICE, IMU, AUTOVON TELEPHONE)
SDMX (TSB)
RING BUS AMP (2)
TIMING DISTRIBUTION
LINE DRIVER INTERFACE
MATRIX INTERFACE
CROSS POINT DRIVERS
CROSSPOINTS
LINE DRIVER INTERFACE
ANALOG SCANNER
CIRCUIT SWITCH SUMMARY ALARM
AUXILIARY SPECIAL CIRCUITS PATCH PANEL
KY-3 ADAPTERS SF ADAPTERS
E&M ADAPTERS
SPECIAL CIRCUIT (12)
LINE DRIVER INTERFACE
TIMING DISTRIBUTION
SPECIAL CIRCUITS GROUP C01-01-03
SPECIAL CIRCUIT CONTROL
SDS GROUP C01-01-01
POWER PROCESSOR
DC LOADS (CRITICAL)
AC LOADS (CRITICAL)

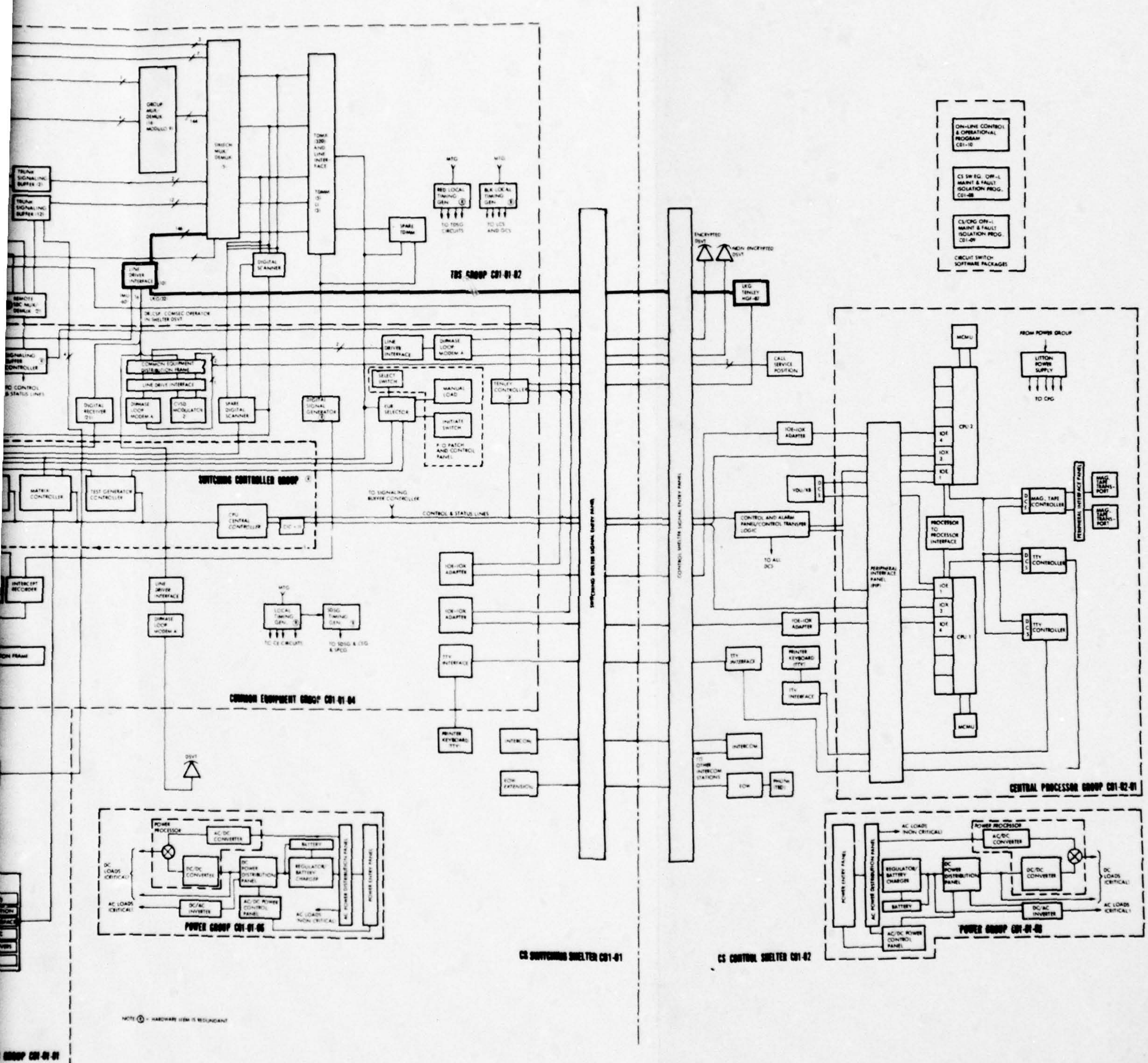


Figure 4-2. Circuit Switch Block Diagram

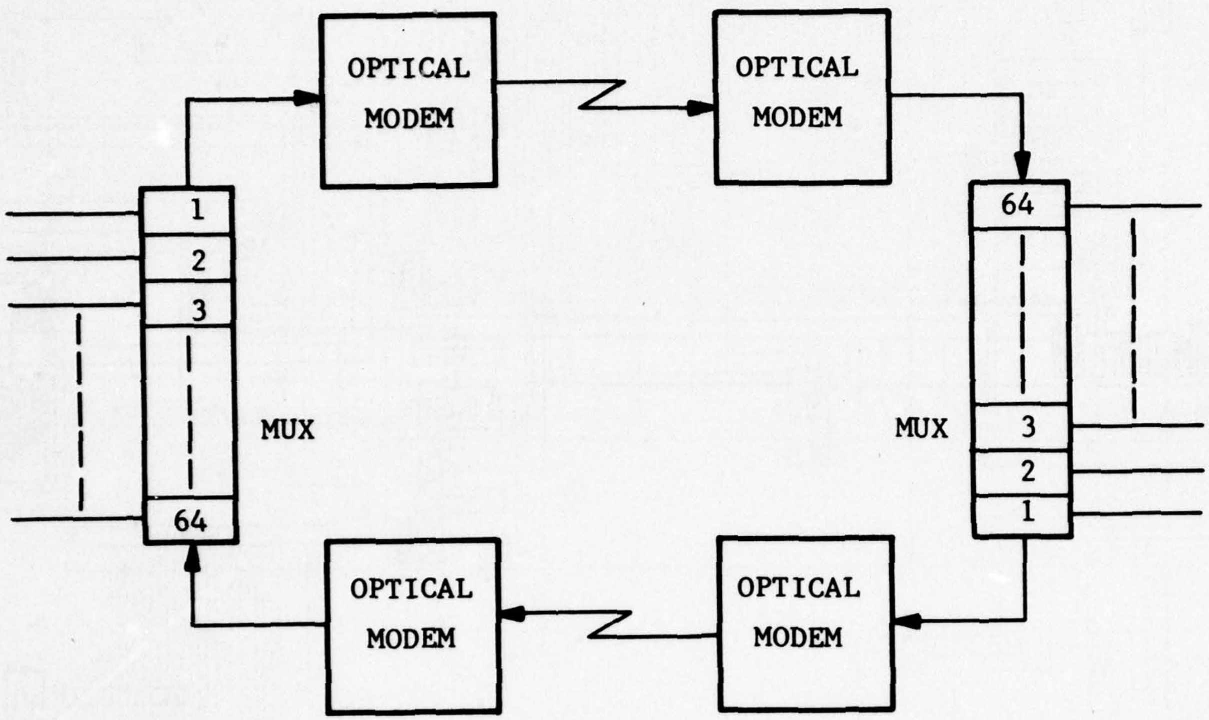


Figure 4-3. Typical Optical Fiber Link

Digital transmission groups make an appearance at the TDMX via the path indicated by the dotted and heavy lines on the left-hand side of Figure 4-2. This path includes the Signal Entry Panel (SEP), TDSG Line Patch Panel, Group Modem (for timing extraction), Group Buffer (for amplification), Trunk Encryption Device (TED) Patch Panel, Group Framing Unit (for synchronization), and Group Mux/Demux (for reconfiguration) prior to the TDMX appearance. Although the proposed fiber optic LKG link can be connected to the SEP, a more desirable interface located at the TED Patch Panel is recommended. Use of this interface permits elimination of several functions (SEP, TSDG Patch Panel, Group Modem, and Buffer) that are not required for LKG link operation, as indicated by the dotted lines. The TED Patch Panel contains jacks for convenient interconnection, thus requiring no changes to existing hardware. In addition, this interface includes the Group Framing Unit that provides the means for synchronization, thus simplifying incorporation of a necessary function, as indicated by the heavy lines. Lastly, the TED Patch Panel usually provides access for insertion of trunk encryption devices if required; therefore, use of this interface will not displace necessary equipment.

This recommended interconnectivity is illustrated in Figure 4-4. It still includes a 1 x 64 multiplex, optical receiver/transmitter pair and optical fiber for each link, and requires a synchronization means. Since the proposed link includes the Group Framing Unit, the specific synchronization technique must be compatible with the AN/TTC-39 transmission requirements, as discussed in a following sub-section.

4.1.3 Physical Interfaces

Figure 4-5 illustrates the physical interconnections of the LKG fiber optic link to the TENLEY HGF-82 rack in the Control Shelter and to the TED Patch Panel in the Switching Shelter, respectively.

Interconnection at point A will be made via four 128-pin MS connectors directly at the rack. The signals associated with point A consist of two full-duplex plain-text and cipher-text channels for each of the sixty-four LKG units. These signal names and their physical pin locations are listed in Appendix A, Section 1.

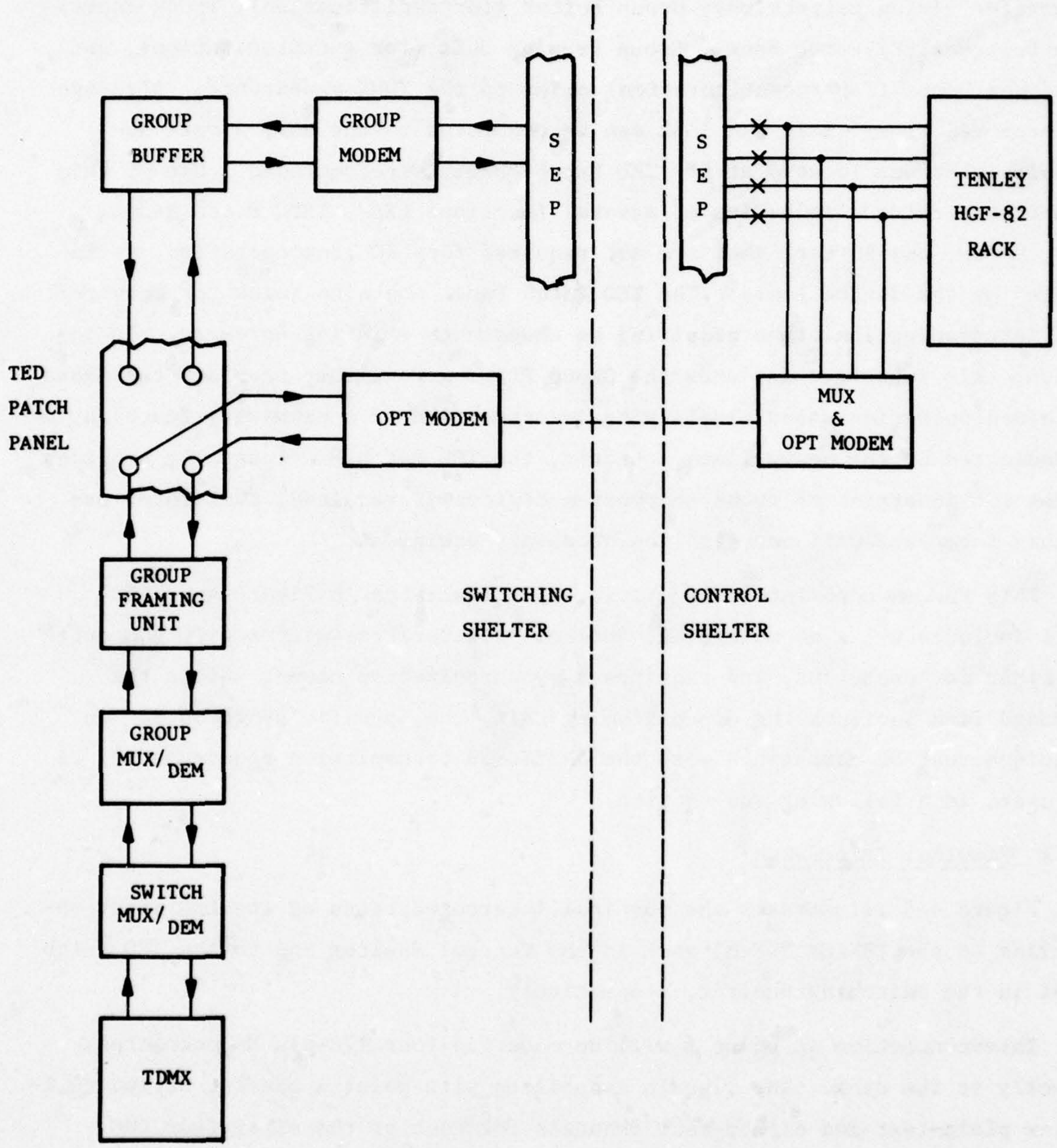


Figure 4-4. Optical Interface for LKG Link

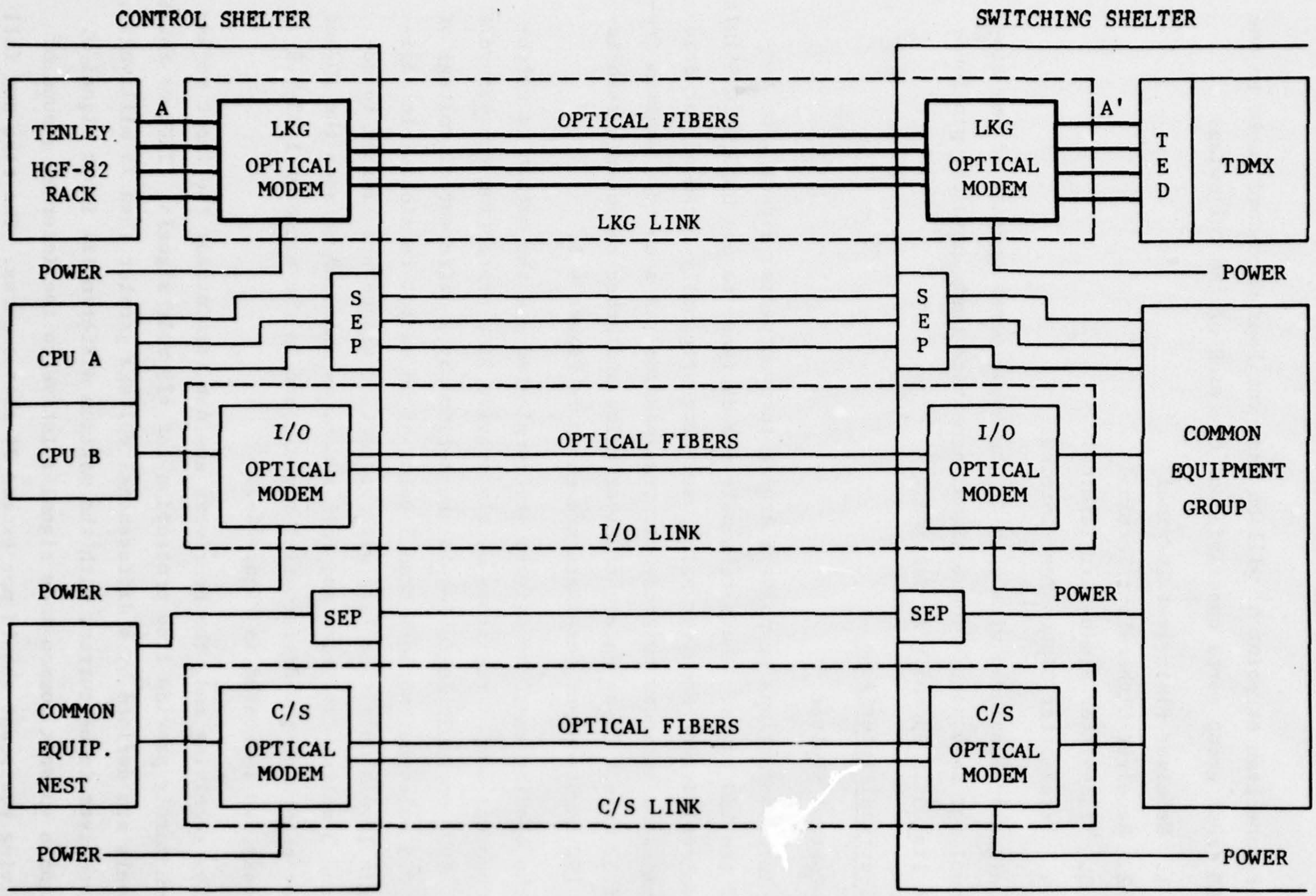


Figure 4-5. Block Diagram

Interconnection at point A[1] will be made vai four patchcord jacks to one of the TED trunk group ports consisting of one each of the following:

1. Receiver Plain-Text Terminal
2. Receiver Cipher-Text Terminal
3. Transmitter Plain-Text Terminal
4. Transmitter Cipher-Text Terminal

The signals associated with each of the above ports consist of one simplex channel for each port. These signal names and their physical pin locations are listed in Appendix A, Section 2.

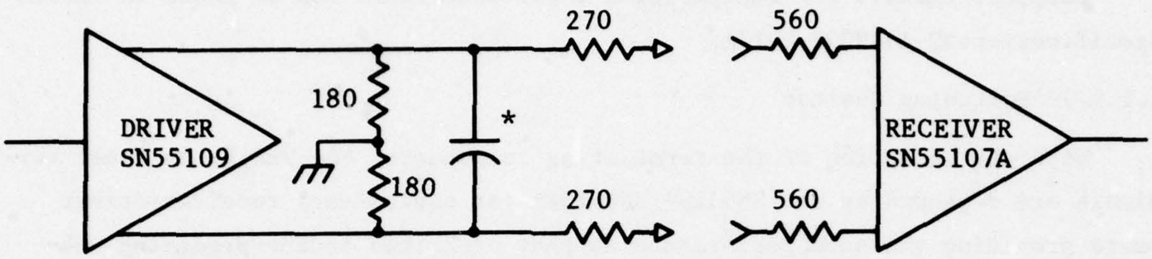
4.1.4 Electrical Interfaces

4.1.4.1 Control Shelter

The interconnections at point A are in turn connected directly to terminals of the LKG units. These terminals are designed to use SN55109/SN55107A (or equivalent) driver/receiver pairs, and were originally intended for driving unterminated balanced twisted-pair transmission lines up to a maximum frequency of 32 KB/s. These receiver/driver pairs and other components associated with LKG input/output terminals are shown in Figure 4-6.

At the sending end, the drivers are terminated and the output is referenced to ground; output resistors merely provide line protection for ± 25 volt signals. TRUE or FALSE logic levels are defined by a differential voltage of at least 0.3 volts but no more than 3 volts at an output terminal. In addition, logic levels on either line with respect to ground are limited to between 0 and 3 volts. The rise and fall times, as measured between the 10 and 90 percent points of the differential signal, are in the range of 1.25-2.5 microseconds, as indicated in Figure 4-7.

At the receiving end, the receivers are not terminated; the input resistors shown merely provide line protection for ± 25 volt signals. TRUE or FALSE logic levels are defined by a differential voltage greater than 25 millivolts, and the receiver input current with the maximum differential input signal of 3 volts and a ± 3 volt common mode signal relative to the internal ground of the receiving equipment should not exceed 74 microamperes. The rise and fall



*CAPACITOR VALUE BASED ON LINE CHARACTERISTICS
EXTERNAL TRANSMISSION LINE DRIVERS USE 2200 PF

Figure 4-6. TENLEY HGF-82 Rack Interface Circuits

$t_{rd} = t_{fd}$ = RISE OR FALL TIME (10-90%)-DATA: Minimum 1.25 μs
Maximum 2.5 μs

Figure 4-7. TENLEY HGF-82 Rack Output Waveform

times for the receiver are in the range of 1.25-3.0 microseconds, as indicated in Figure 4-8. No more than one such receiver can be used to terminate lines interconnecting the AN/TTC-39 and the TENLEY HGF-82 rack.

Complete details for implementing these interfaces can be found in TRITAC Specification TT-A3-9002-0017A.

4.1.4.2 Switching Shelter

With the exception of the terminating components, the TED Patch Panel terminals are designed to use SN55109/SN55107A (or equivalent) receiver/driver pairs providing the same performance as that described in the preceding subsection.

In this instance, both the receiver and driver are terminated with respect to logic ground, as illustrated in Figure 4-9.

4.1.5 Functional Requirements

Functionally, the individual LKG channels at the TENLEY HGF-82 rack will be time-multiplexed within the Control Shelter and transmitted via optical fibers to the Switching Shelter to make an appearance at the TED Patch Panel as a digital transmission group. In this form, the serialized LKG data stream must be compatible with the frame acquisition and synchronization procedures performed by the hardware in the Group Framing Unit. Such compatibility requires both provisions for inserting framing patterns during acquisition and in-sync operation and transmission at one of the acceptable data and framing rates.

Frame acquisition is initiated by the Group Framing Unit on command from the Central Processing Unit (CPU). The Group Framing Unit begins transmitting an Out-of-Sync framing pattern (all ONES in the framing sub-channel with all other channels set to ZERO) in order to alert the interfacing (i.e., LKG link) equipment to begin a cooperative frame acquisition process. The interfacing equipment must respond by sending the same Out-of-Sync framing pattern back to the Group Framing Unit, which begins to count the framing bits. When a sufficient quantity has been received and counted to satisfy an acquisition algorithm, the Group Framing Unit then transmits an In-Sync framing pattern (alternate ONES and ZEROS in the framing sub-channel with all other bits set

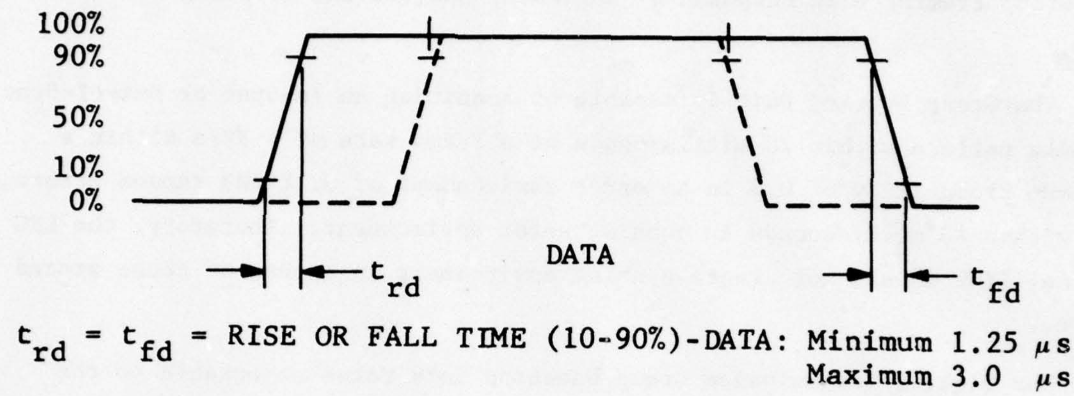


Figure 4-8. TENLEY HGF-82 Rack Input Waveform

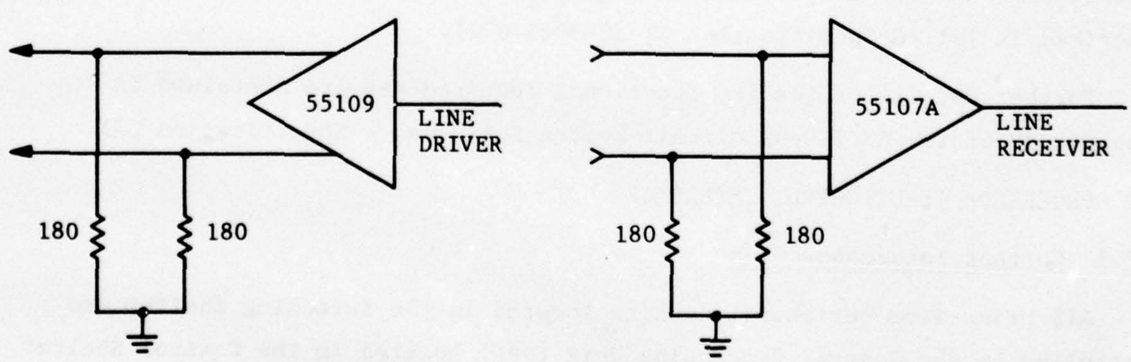


Figure 4-9. TED Driver/Receivers

to ZERO). Transmission of this In-Sync framing pattern continues until a corresponding In-Sync framing pattern is detected on the received channel. The Group Framing Unit responds by informing the CPU and resuming normal data flow.

The Group Framing Unit is capable of acquiring an In-Sync or Out-of-Sync framing pattern within 20 milliseconds at a frame rate of 4 KB/s within a minimum probability of 0.9 in an error environment of 0.1% BER random errors, and within 40 milliseconds in a burst error environment. Therefore, the LKG optical link should not create a noise environment in excess of those stated above.

The Digital Transmission Group baseband data rates acceptable to the AN/TTC-39 are shown in Table 4-2. The total of 64 LKG channels plus the framing channel necessitates use of the 72 channel rate, or operation at 2.304 MB/s. Because of the transition from individual channels in the Control Shelter to time-multiplexed channels in the Switching Shelter, the relation of physical terminals to assigned time slots must be maintained, using the framing channel as reference.

The traffic flowing in the LKG optical link is such as to require that the link design be consistent with TEMPEST requirements as described in TRITAC Specification TT-B1-1101-0001A (Paragraph 3.3.8) and with COMSEC standards as described in TRITAC Specification TT-A3-9005-0021.

Further details of the LKG functional requirements are contained in Appendix 39 of the AN/TTC-39 Circuit Switch Performance Specification C01.

4.2 PROCESSOR INPUT/OUTPUT INTERFACE

4.2.1 Current Interconnection

All prime-item peripheral devices located in the Switching Shelter are controlled by the Central Processing Unit (CPU) located in the Control Shelter. Input/Output operations are initiated by the CPU but carried out by the Input/Output Unit (IOU). This unit provides the control and communication between the peripheral devices, CPU and memory units, as illustrated in Figure 4-10.

TABLE 4-2 DIGITAL TRANSMISSION GROUP DATA RATES

CHANNELS PER DTG	DTG BIT RATE (KB/S) @ 32 KB/S PER CHANNEL
8	256
9	288
16	512
18	576
32	1024
36	1152
48	1536
64	2048
72	2304
128	4096
144	4608

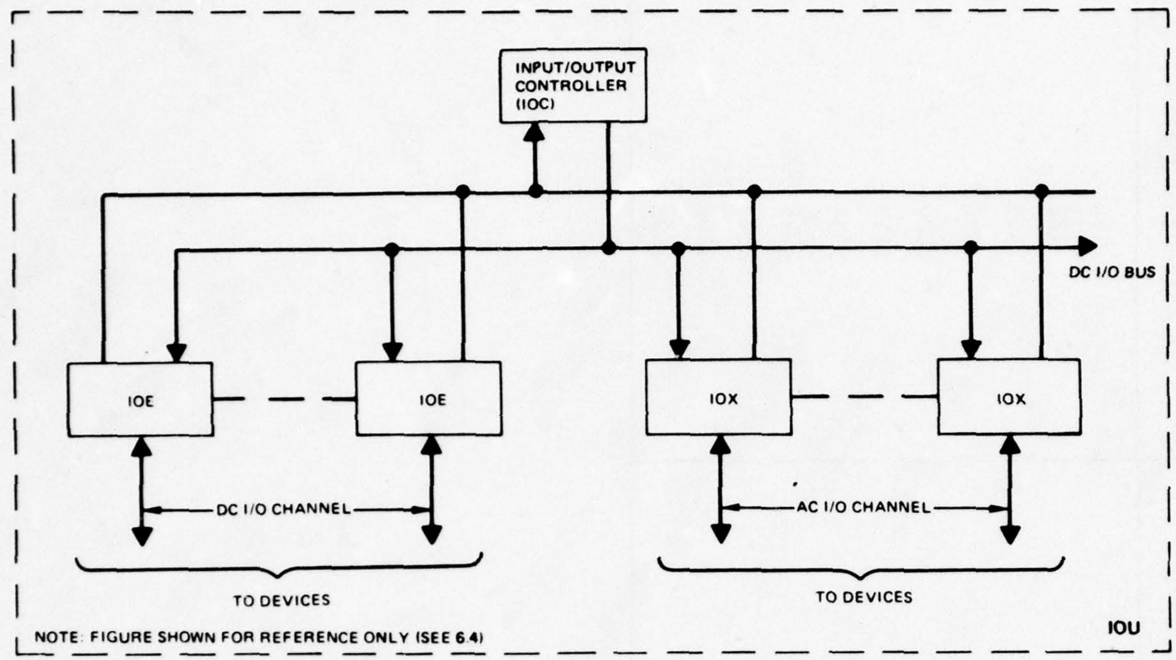


Figure 4-10. IOU Interfaces

The IOU communicates with devices via two types of interfaces: namely the ac Input/Output Exchange (IOX) and the dc Input/Output Expander (IOE). The IOE is used to communicate with devices within the same shelter, whereas the IOX contains additional driver circuitry for communication with devices in the other shelter.

The IOE and IOX interfaces each can service only eight unique peripheral devices. As a result of past design modifications, additional devices have been added in the Switching Shelter. One of the IOE interfaces was converted to an IOX interface by adding the necessary driving circuitry to service these devices. Therefore, the IOU requires two cables for performing input/output functions, each of which is the electrical equivalent of the other.

Each cable contains twenty-six twisted-pair transmission lines of which twenty are used for information transfer, as illustrated in Figure 4-11. The five categories of signals can be described as follows:

A. Information lines (bi-directional, bused). Nine lines are used for the purpose of transmitting information between the channel and devices. The nine lines are used for the following functional purposes:

1. Data Signals. Information lines 0 through 7 contain the data byte. Information line P provides odd parity on the eight information lines during the data transmission phase of communication. When word transmission is used, four bytes are transmitted sequentially (each with parity). For byte transmission, a single byte is transmitted as a result of a data transfer sequence. The most significant byte is transmitted first in word transmissions (bits 0 through 7, followed by 8 through 15, 16 through 23, then 24 through 31).

2. Address Selection. The eight lines (0 through 7) are used in conjunction with the Enable line or Command line to select a particular peripheral device. The device is selected if the Address Selection line corresponding to the device's address switch setting is pulsed coincident with an Enable or Command

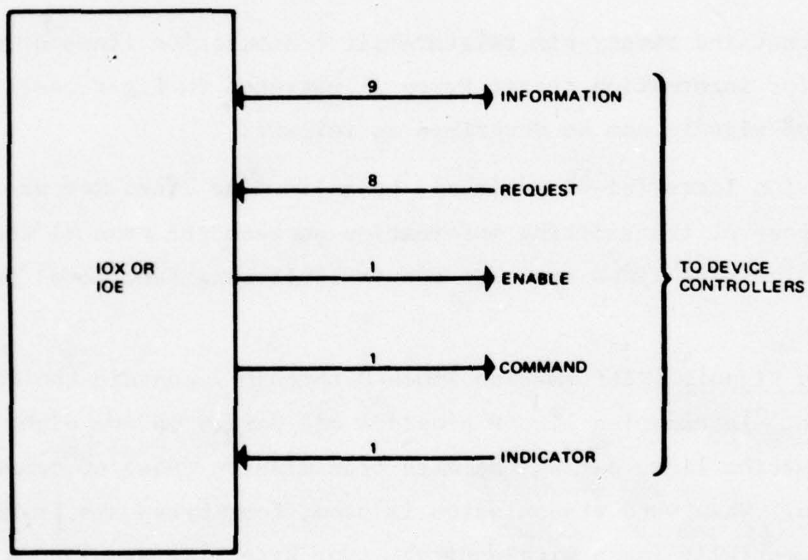


Figure 4-11. Channel Interface Signal Lines

signal. Information line P is not used to indicate odd parity during the address selection phase.

3. Device Control. The information lines are used to signify specific operational actions to be performed by the device. The information appearing on the information lines specifies the operations to be performed. Information line P is pulsed to indicate odd parity during the control selection phase.

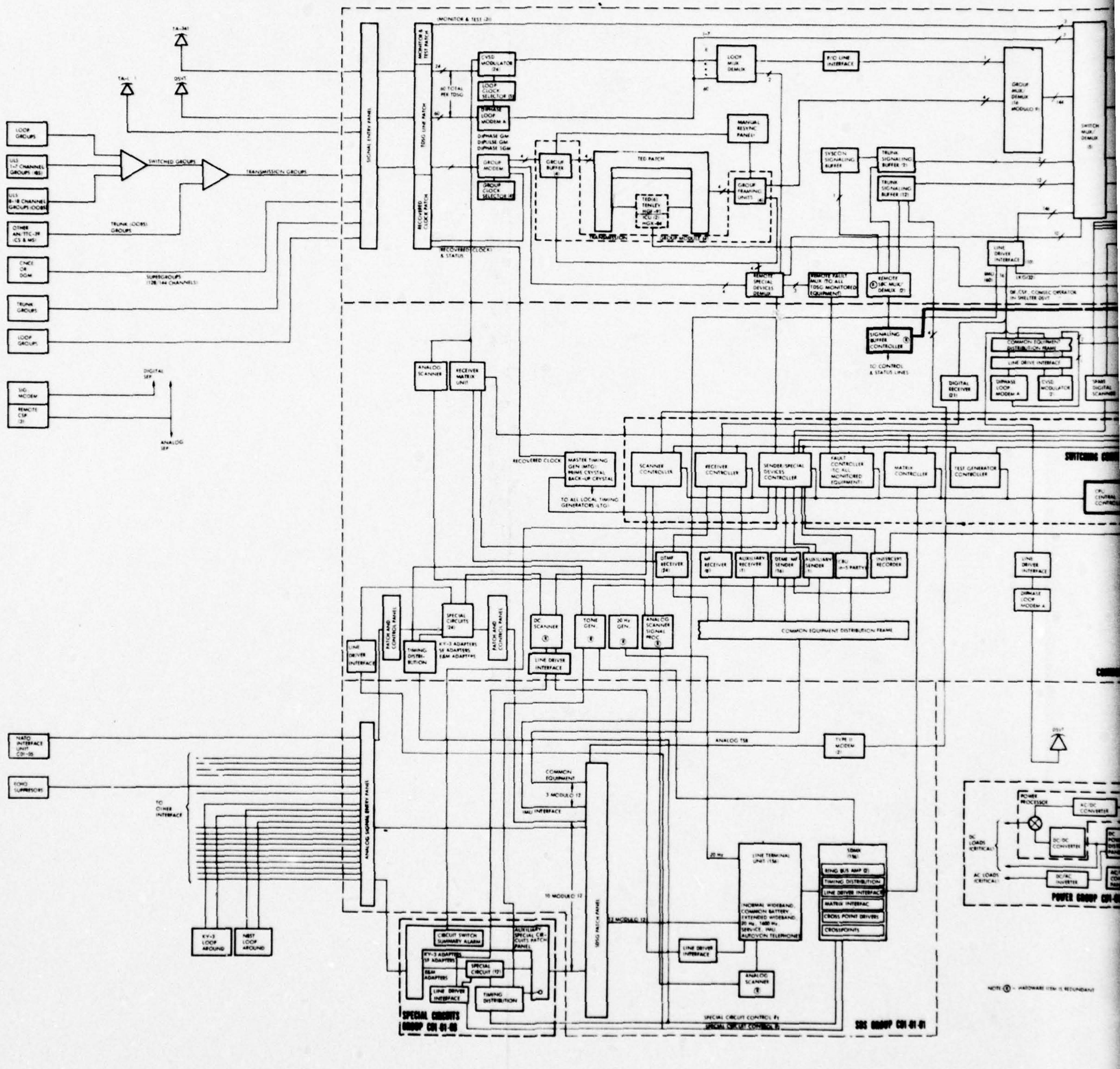
B. Request Lines (to Computer). Each channel contains eight Request lines. One of the eight Request lines is assigned to each functional device connected on that channel. The Request line utilized by a particular device defines the least significant bits (minor channel) of the device address for that device.

C. Enable Line (from Computer). The Enable line is used on conjunction with the information lines to perform address selection. When the signal appears, the transfer of information that follows consists of either data flowing between the computer and peripheral devices or a device interrupt. This signal is also used in conjunction with the Command line to signify a Master Reset.

D. Command Line (from Computer). The Command line is used in conjunction with the Information lines to perform address selection. When the Command signal appears, the information byte that follows the signal is an encoded command operation. Further information flow is predicated upon the actual command issued. The Command line is also used in conjunction with the Enable line to signify a Master Reset.

E. Indicator Line (to Computer). The Indicator line is used to acknowledge receipt of a CPU command, and to initiate a device interrupt.

The present interconnectivity of the IOX and IOE-adapted IOX intershelter signals is illustrated in Figure 4-12. These signals flow between the Signal Entry Panels of the respective shelters via cables WXX5 through WXX8. As noted in Table 4-1, redundant cables WXX5 and WXX6 contain, in addition to Input/Output channels for the added peripheral devices mentioned previously,



LOOP GROUPS
ULS 1-7 CHANNEL GROUPS (8G)
ULS 8-18 CHANNEL GROUPS (DOBS)
OTHER AN/TTC-39 (CS & MS)
CNCE OR DGM
TRUNK GROUPS
LOOP GROUPS
SWITCHED GROUPS
TRANSMISSION GROUPS
TRUNK (DOBS) GROUPS
SUPERGROUPS (128/144 CHANNELS)
SIG MODEM
REMOTE CSP (3)
DIGITAL SEF
ANALOG SEF
TA-341
TA-1
DSVT
SIGNAL ENTRY PANEL
MONITOR & TEST PATCH
TDSG LINE PATCH
RECOVERED CLOCK PATCH
(MONITOR & TEST (2))
CVSD MODULATOR (24)
LOOP CLOCK SELECTOR
DIPHASE LOOP MODEM A
DIPHASE GM
DIPULSE GM
DIPHASE SGM
GROUP MODEM
GROUP CLOCK SELECTOR
60 TOTAL PER TDSG
RECOVERED CLOCK & STATUS
LOOP MUX DEMUX
P/C LINE INTERFACE
MANUAL RESYNC PANEL
GROUP BUFFER
TED PATCH
GROUP FRAMING UNITS
SYSCON SIGNALING BUFFER
TRUNK SIGNALING BUFFER (2)
TRUNK SIGNALING BUFFER (12)
GROUP MUX/ DEMUX MODULO 9
SWITCH MUX/ DEMUX
LINE DRIVER INTERFACE
REMOTE SPECIAL DEVICES DEMUX
REMOTE FAULT MUX (TC ALL TDSG MONITORED EQUIPMENT)
REMOTE SBC MUX/ DEMUX (2)
DF, CSF, COMSEC OPERATOR IN-SHELTER DEVT
SIGNALING BUFFER CONTROLLER
TC CONTROL & STATUS LINES
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVE INTERFACE
DIGITAL RECEIVER (21)
DIPHASE LOOP MODEM A
CVSD MODULATOR (2)
SPARE DIGITAL SCANNER
ANALOG SCANNER
RECEIVER MATRIX UNIT
RECOVERED CLOCK
MASTER TIMING GEN (MTG) PRIME CRYSTAL BACK-UP CRYSTAL
TO ALL LOCAL TIMING GENERATORS (LTG)
SCANNER CONTROLLER
RECEIVER CONTROLLER
SENDER/SPECIAL DEVICES CONTROLLER
FAULT CONTROLLER (TC ALL MONITORED EQUIPMENT)
MATRIX CONTROLLER
TEST GENERATOR CONTROLLER
SWITCHING CO
CPU CENTRAL CONTROL
DTMF RECEIVER (24)
MF RECEIVER
AUXILIARY RECEIVER
DTMF MF SENDER (16)
AUXILIARY SENDER
CBU (4-5 PARTY)
INTERCEPT RECORDER
LINE DRIVER INTERFACE
DIPHASE LOOP MODEM A
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVER INTERFACE
PATCH AND CONTROL PANEL
TIMING DISTRIBUTION
SPECIAL CIRCUITS (24)
KY-3 ADAPTERS SF ADAPTERS E&M ADAPTERS
PATCH AND CONTROL PANEL
DC SCANNER
TONE GEN
20 Hz GEN
ANALOG SCANNER SIGNAL PROC
LINE DRIVER INTERFACE
NATO INTERFACE UNIT CDI-05
ECHO SUPPRESSORS
TO OTHER INTERFACE
ANALOG SIGNAL ENTRY PANEL
KY-3 LOOP AROUND
NBST LOOP AROUND
ANALOG TSB
TYPE II MODEM (2)
COMMON EQUIPMENT
3 MODULO 12
IMU INTERFACE
10 MODULO 12
12 MODULO 12
SPSG PATCH PANEL
20 Hz
LINE TERMINAL UNIT (TSE)
(NORMAL WIDEBAND, COMMON BATTERY EXTENDED WIDEBAND, 20 Hz, 1600 Hz SERVICE, IMU, AUTOVON TELEPHONE)
SDMX
RING BUS AMP
TIMING DISTRIBUTION
LINE DRIVER INTERFACE
MATRIX INTERFAC
CROSS POINT DRIVERS
CROSSPOINTS
LINE DRIVER INTERFACE
ANALOG SCANNER
CIRCUIT SWITCH SUMMARY ALARM
AUXILIARY SPECIAL CIRCUITS PATCH PANEL
KY-3 ADAPTERS SF ADAPTERS
E&M ADAPTERS
SPECIAL CIRCUIT (72)
LINE DRIVER INTERFACE
TIMING DISTRIBUTION
SPECIAL CIRCUITS GROUP CDI-01-08
SPECIAL CIRCUIT CONTROL #1
SPECIAL CIRCUIT CONTROL #2
SBS GROUP CDI-01-01
POWER PROCESSOR
AC/DC CONVERTER
DC/DC CONVERTER
DC LOADS (CRITICAL)
AC LOADS (CRITICAL)
DC/AC INVERTER
POWER GROUP CDI-0
NOTE: HARDWARE ITEM IS REDUNDANT

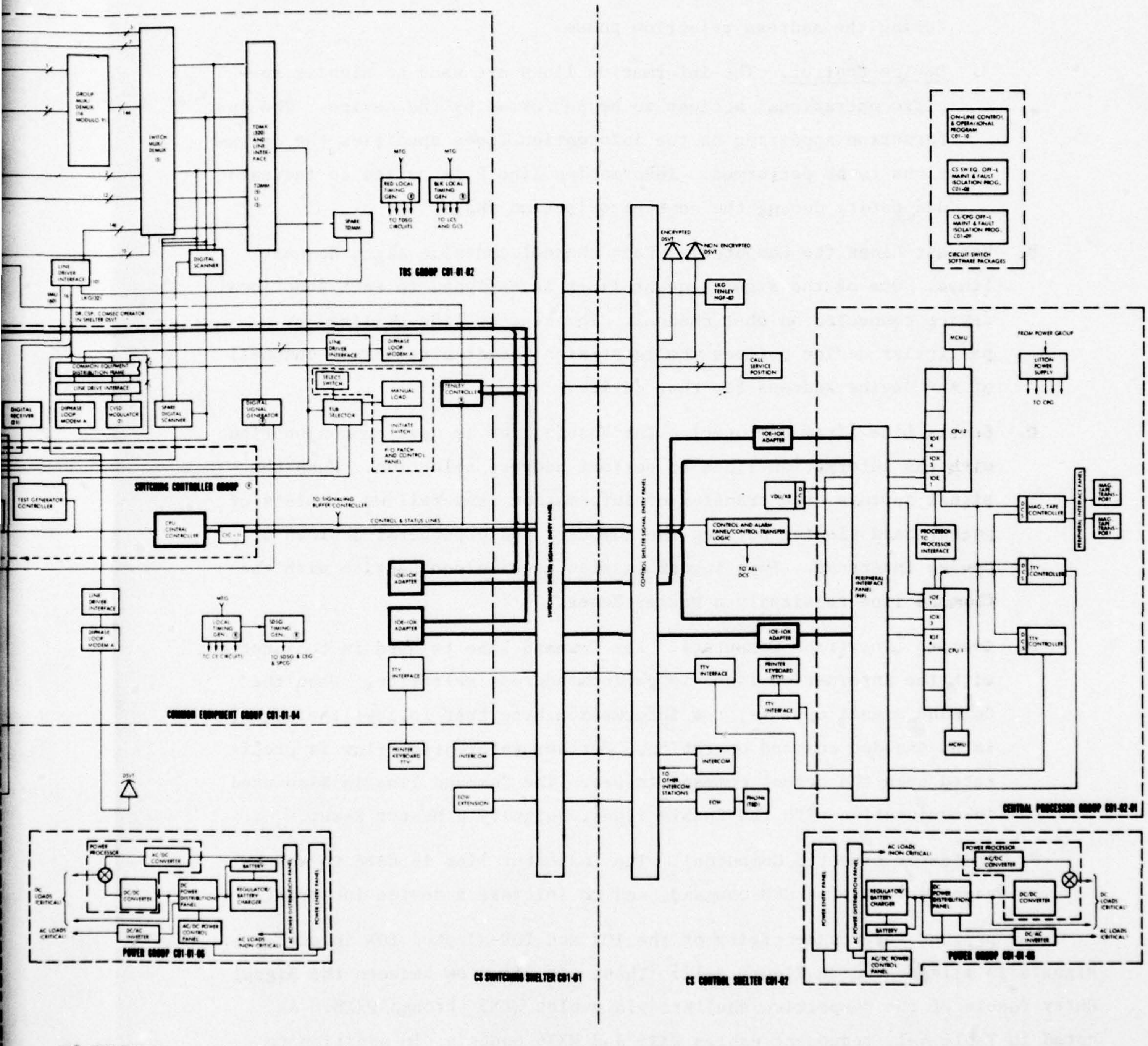


Figure 4-12. Circuit Switch Block Diagram

several TENLEY status channels on the spare lines. This is not the case for cables WXX7 and WXX8; i.e., these latter cables carry only the Input/Output channels for servicing eight devices.

4.2.2 Fiber Optic Interconnectivity

In order to meet overall AN/TTC-39 reliability requirements, two CPUs are employed and complementary fully redundant interconnections are provided to all peripheral devices. For purposes of a feasibility study, however, redundancy is an unnecessary luxury. Therefore, it is recommended that a single link be developed using fiber optics. Not only will the resulting cost savings accrue, but also the advantage of having a parallel operating link for comparison purposes. In addition, set-up time for the fiber optic link will have minimum impact on the normal operation of the AN/TTC-39 because of the availability of the alternate processor. One straightforward approach involves combining the several channels on these two cables into one for transmission via a fiber optic link. However, while cable WXX7 carries the necessary channels for servicing eight peripheral devices, cable WXX5 carries fewer channels for servicing one extra device plus five TENLEY status channels that are completely unrelated to the IOU function. It is therefore further recommended that, for purposes of a feasibility development, only the I/O-related cable be replaced by a fiber optic link. The impact of subsequent addition of channels has minimal effect on the design of the related hardware compared to that of the present timing requirements, as discussed in a following sub-section.

The recommended interconnectivity for cable WXX7 replacement is shown in Figure 4-13. With no changes to existing hardware, points of connection nearest to the respective equipments are those at the Peripheral Interface Panel (PIP) and Common Equipment Group (CEG) in the Control and Switching Shelters, respectively.

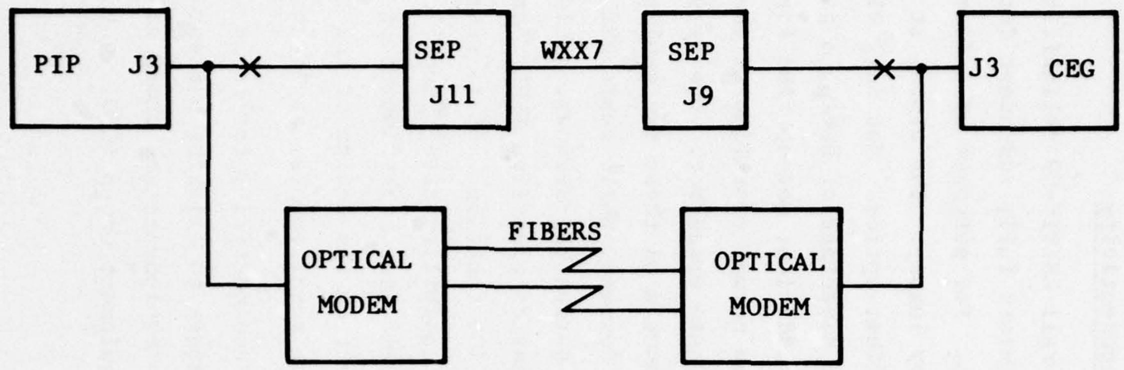


Figure 4-13. Optical Interface for I/O Link

4.2.3 Physical Interfaces

The connections to the Peripheral Interface Panel and Common Equipment Group are denoted as points B and B', respectively, in Figure 4-14. Connections at point B will be made using a 52-pin SM connector. Signals associated with this connector include eight INFORMATION channels, a PARITY channel, eight REQUEST channels, and one each of ENABLE, COMMAND and INDICATOR channels, for a total of twenty channels. The signal names for each of the resulting 40 pins are listed in Appendix B, Section 1.

Connections at point B' will also be made using a 52-pin SM connector. The physical relationship between signal names and pin locations must be identical to that for the connector at point B.

4.2.4 Electrical Interfaces

This I/C fiber optic link must be transparent to the intended signal flow; therefore, the electrical characteristics at the PIP and CEG interfaces are identical.

The interface circuitry normally employed for the IOU channels is illustrated in Figure 4-15. The terminals are transformer-coupled and are designed to drive twisted-pair transmission lines that are terminated as shown. The logic levels for these ac coupled channels are as follows:

a. A logical ONE is defined as a pulse having a width of 180 ±60 nanoseconds and an amplitude of 4.5 ±1.5 volts.
b. A logical ZERO is defined as a signal of amplitude equal to 0.25 ±0.25 volts.

4.2.5 Functional Requirements

Functionally, the various I/O channels must be serialized and time-multiplexed within the Control Shelter for transmission via an optical fiber to the Switching Shelter, where they will be de-multiplexed and converted back into parallel format. The return path must provide for similar operations.

Within the Control Shelter, the optical-related hardware must perform the following functions:

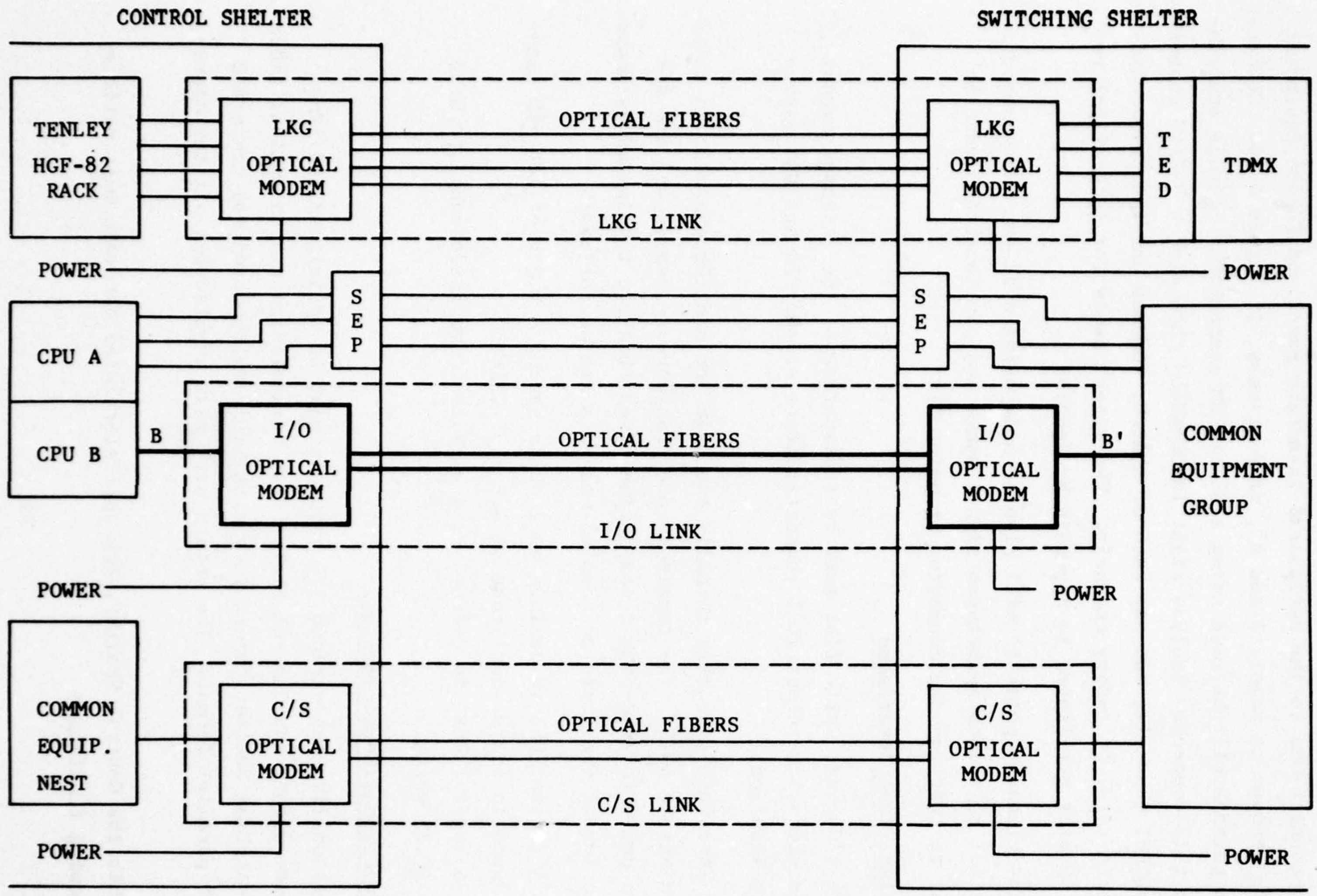


Figure 4-14. Block Diagram

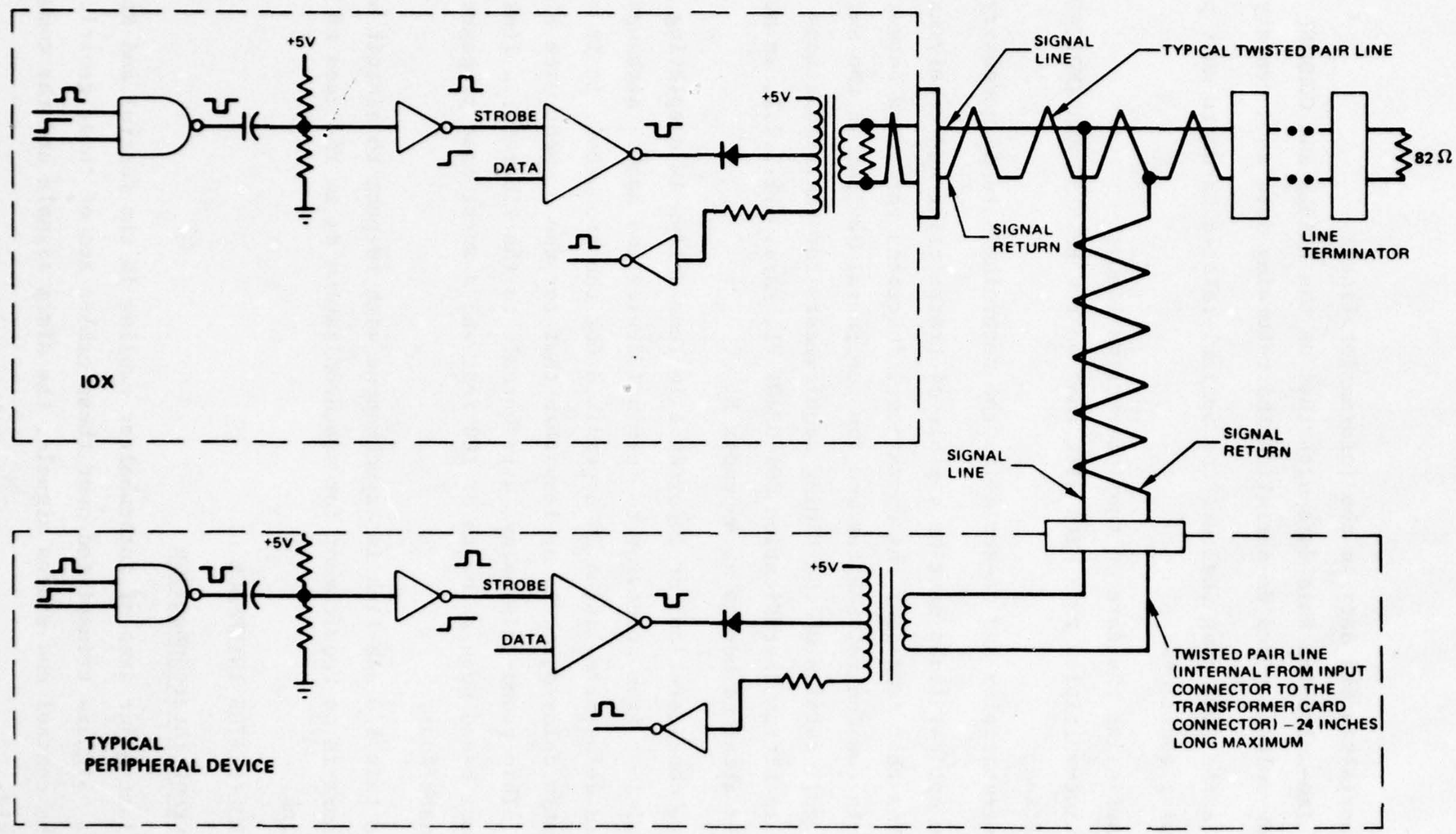


Figure 4-15. I/O Interface Circuits

1. serialize the data on the information lines;
2. time-multiplex this data with that on the ENABLE and COMMAND lines;
3. de-multiplex and de-serialize the returning data as necessary.

Within the Switching Shelter, the optical-related hardware must perform the following functions.

1. serialize the data on the information lines;
2. time-multiplex this data with that on the REQUEST and INDICATOR lines;
3. de-multiplex and de-serialize the returning data as necessary.

These optical links must be capable of transmitting and receiving those bit patterns that represent the operational functions performed between the processor in the Control Shelter and the peripheral devices in the Switching Shelter. Full details of the timing requirements for these functions are contained in Litton Specification C01-02-01 P1, Para. 3.1.2.1.1, an abstract of which is attached hereto as Appendix E.

Timing considerations of importance include delays in completing the operational loop from processor to terminal device and back. Although specific allowed delays are listed in Appendix E for the processor, it is recommended that a delay equal to or less than that for the present wire link be required. This round-trip delay, attributable to the fiber-optic link alone, is 600 nsec, based upon a length of 100 feet and a worst case propagation delay of 3 nsec/foot.

Since this I/O sub-link is asynchronous with respect to circuit switch timing, there is no requirement for synchronization as in the case of the LKG sub-link.

4.3 CONTROL/STATUS INTERFACE

4.3.1 Current Interconnection

The last major area of intershelter cabling is the Control and Status interface. Signals transmitted over these cables are of three generic types, namely, the control and status signals, the alarm signals and the communication signals.

The control and status signals are used to control and monitor the following devices in the Control Shelter:

1. TENLEY Controller
2. Signaling Buffer Controller
3. Switching Controller Group
4. Control Transfer Logic

The alarms are generated in the Switching Shelter and transmitted to the Control Shelter via the intershelter cabling, and include the following:

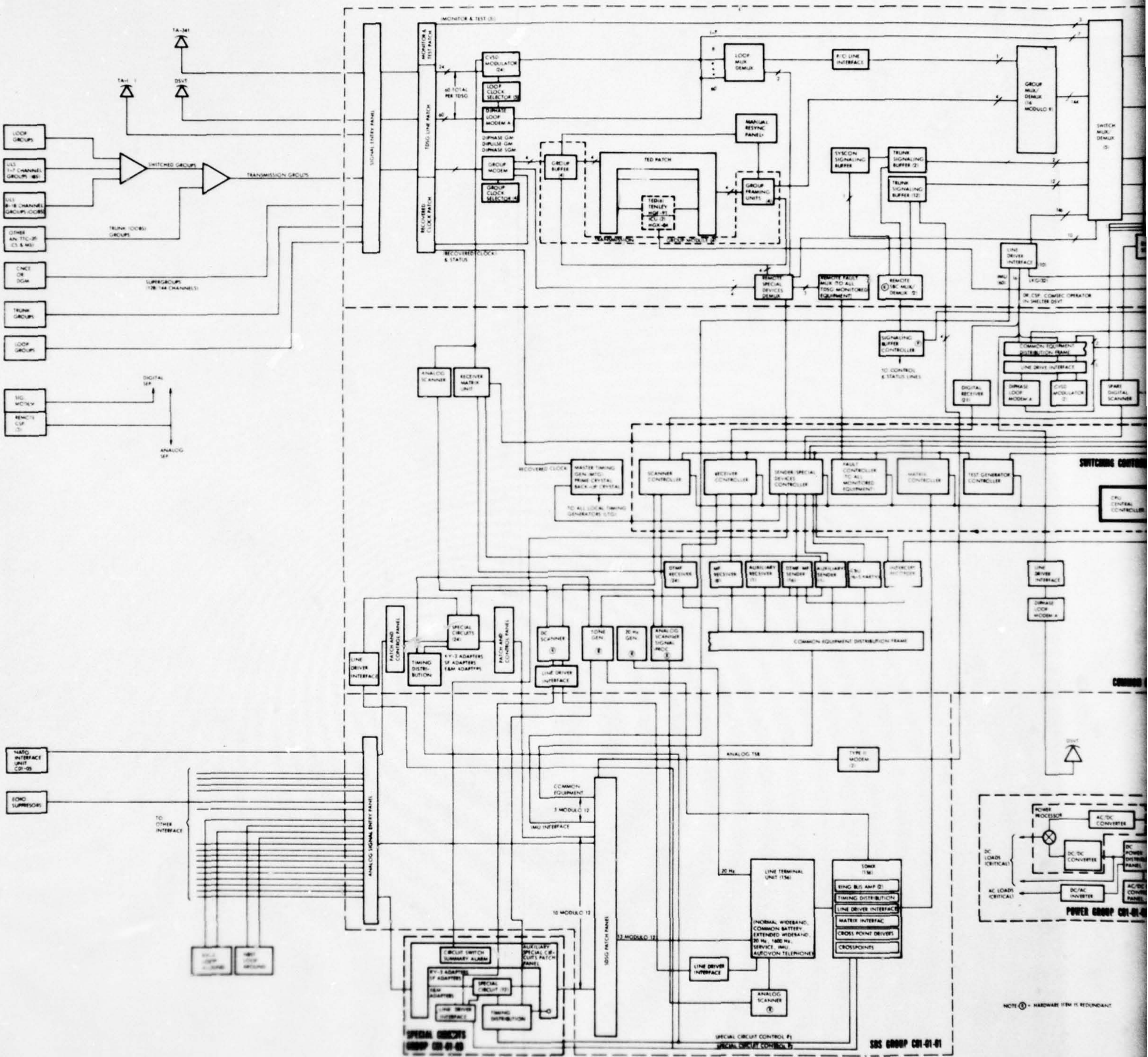
1. Door Interlock
2. Prime Power Interlock
3. Dc Power Interlock
4. Over-Temperature Interlock

The communication signals consist both of voice- and message-related data, and can be classified as either analog or digital. The analog signals include the Call Service Postion (CSP) talking path, Engineering Order Wire, and intercom (final design of the latter two functions has not yet been confirmed). The digital signals include the Digital Secure Voice Terminal (DSVT) and Teletypewriter (TTY).

The above signals are transmitted between shelters via four 26-pair cables identified as WXX9 through WXX12. Cable WXX9 is used primarily for transmission of communication signals. Cables WXX10 and EXX11 are redundant cables used for transmitting the control and status signals. Cable WXX12 is a "catch-all" cable primarily containing the alarm signals. The current signal flow for the Control and Status Interface is illustrated in Figure 4-16.

4.3.2 Fiber Optic Interconnectivity

Although a multiplicity of functions are indicated in Figure 4-16, the terminals associated with these functions are convened into four cable terminals at the Common Equipment Nest and Common Equipment Group in the Control and Switching Shelters, respectively. Therefore, these terminals are convenient points for interfacing the proposed fiber optic link.



TA-341
TA-1
DSVT
LOOP GROUPS
ULS 1-7 CHANNEL GROUPS (IBS)
ULS 8-18 CHANNEL GROUPS (OOBS)
OTHER AN/TTC-39 (CS & MS)
CNCE OR DGM
TRUNK GROUPS
LOOP GROUPS
SWITCHED GROUPS
TRANSMISSION GROUPS
TRUNK (OOBS) GROUPS
SUPERGROUPS (128/144 CHANNELS)
DIGITAL SEP
ANALOG SEP
REMOTE CSP
MONITOR & TEST
SIGNAL ENTRY PANEL
MONITOR & TEST PATCH
TDSG LINE PATCH
RECOVERED CLOCK PATCH
RECOVERED CLOCK & STATUS
CVSD MODULATOR (24)
LOOP CLOCK SELECTOR
DIPHASE LOOP MODEM A
60 TOTAL PER TDSG
DIPHASE GM
DIPULSE GM
DIPHASE SGM
GROUP MODEM
GROUP CLOCK SELECTOR
GROUP BUFFER
TED PATCH
MANUAL RESYNC PANEL
GROUP FRAMING UNITS
LOOP MUX DEMUX
P/O LINE INTERFACE
GROUP MUX/DEMUX (14 MODULO 9)
SWITCH MUX/DEMUX (5)
SYSCON SIGNALING BUFFER
TRUNK SIGNALING BUFFER (2)
TRUNK SIGNALING BUFFER (12)
REMOTE SPECIAL DEVICES DEMUX
REMOTE FAULT MUX (TO ALL TDSG MONITORED EQUIPMENT)
REMOTE TBC MUX/DEMUX (2)
LINE DRIVER INTERFACE
OR CSP, COMSEC OPERATOR IN SHELTER DSVT
SIGNALING BUFFER CONTROLLER
TO CONTROL & STATUS LINES
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVE INTERFACE
DIGITAL RECEIVER (21)
DIPHASE LOOP MODEM A
CVSD MODULATOR
SPARE DIGITAL SCANNER
ANALOG SCANNER
RECEIVER MATRIX UNIT
RECOVERED CLOCK
MASTER TIMING GEN (MTG) PRIME CRYSTAL BACK-UP CRYSTAL
TO ALL LOCAL TIMING GENERATORS (LTG)
SCANNER CONTROLLER
RECEIVER CONTROLLER
SENDER/SPECIAL DEVICES CONTROLLER
FAULT CONTROLLER (TO ALL MONITORED EQUIPMENT)
MATRIX CONTROLLER
TEST GENERATOR CONTROLLER
SWITCHING CONTR
CPU CENTRAL CONTROLLER
DTMF RECEIVER
MF RECEIVER
AUXILIARY RECEIVER
DTMF MF SENDER
AUXILIARY SENDER
INTERCEPT RECORDER
COMMON EQUIPMENT DISTRIBUTION FRAME
LINE DRIVER INTERFACE
DIPHASE LOOP MODEM A
LINE DRIVER INTERFACE
PATCH AND CONTROL PANEL
SPECIAL CIRCUITS (24)
TIMING DISTRIBUTION
KY-3 ADAPTERS
SF ADAPTERS
E&M ADAPTERS
DC SCANNER
TONE GEN
20 Hz GEN
ANALOG SCANNER SIGNAL PROC
LINE DRIVER INTERFACE
COMMON
NATO INTERFACE UNIT C01-05
ECHO SUPPRESSORS
TO OTHER INTERFACE
ANALOG SIGNAL ENTRY PANEL
ANALOG TSB
TYPE II MODEM (2)
COMMON EQUIPMENT
2 MODULO 12
IMU INTERFACE
10 MODULO 12
12 MODULO 12
SDSG PATCH PANEL
20 Hz
LINE TERMINAL UNIT (156)
(NORMAL, WIDEBAND, COMMON BATTERY, EXTENDED WIDEBAND, 20 Hz, 1600 Hz, SERVICE, IMU, AUTOVON TELEPHONE)
SDMX (156)
RING BUS AMP (2)
TIMING DISTRIBUTION
LINE DRIVER INTERFACE
MATRIX INTERFAC
CROSS POINT DRIVERS
CROSSPOINTS
LINE DRIVER INTERFACE
ANALOG SCANNER
CIRCUIT SWITCH SUMMARY ALARM
KY-3 ADAPTERS
SF ADAPTERS
E&M ADAPTERS
SPECIAL CIRCUIT (3)
AUXILIARY SPECIAL CIRCUITS PATCH PANEL
LINE DRIVER INTERFACE
TIMING DISTRIBUTION
SPECIAL CIRCUITS GROUP C01-01-03
SPECIAL CIRCUIT CONTROL #1
SPECIAL CIRCUIT CONTROL #2
SBS GROUP C01-01-01
POWER PROCESSOR
AC/DC CONVERTER
DC/DC CONVERTER
DC POWER DISTRIBUTION PANEL
DC LOADS (CRITICAL)
AC LOADS (CRITICAL)
DC/AC INVERTER
POWER GROUP C01-01-0
NOTE: ® = HARDWARE ITEM IS REDUNDANT

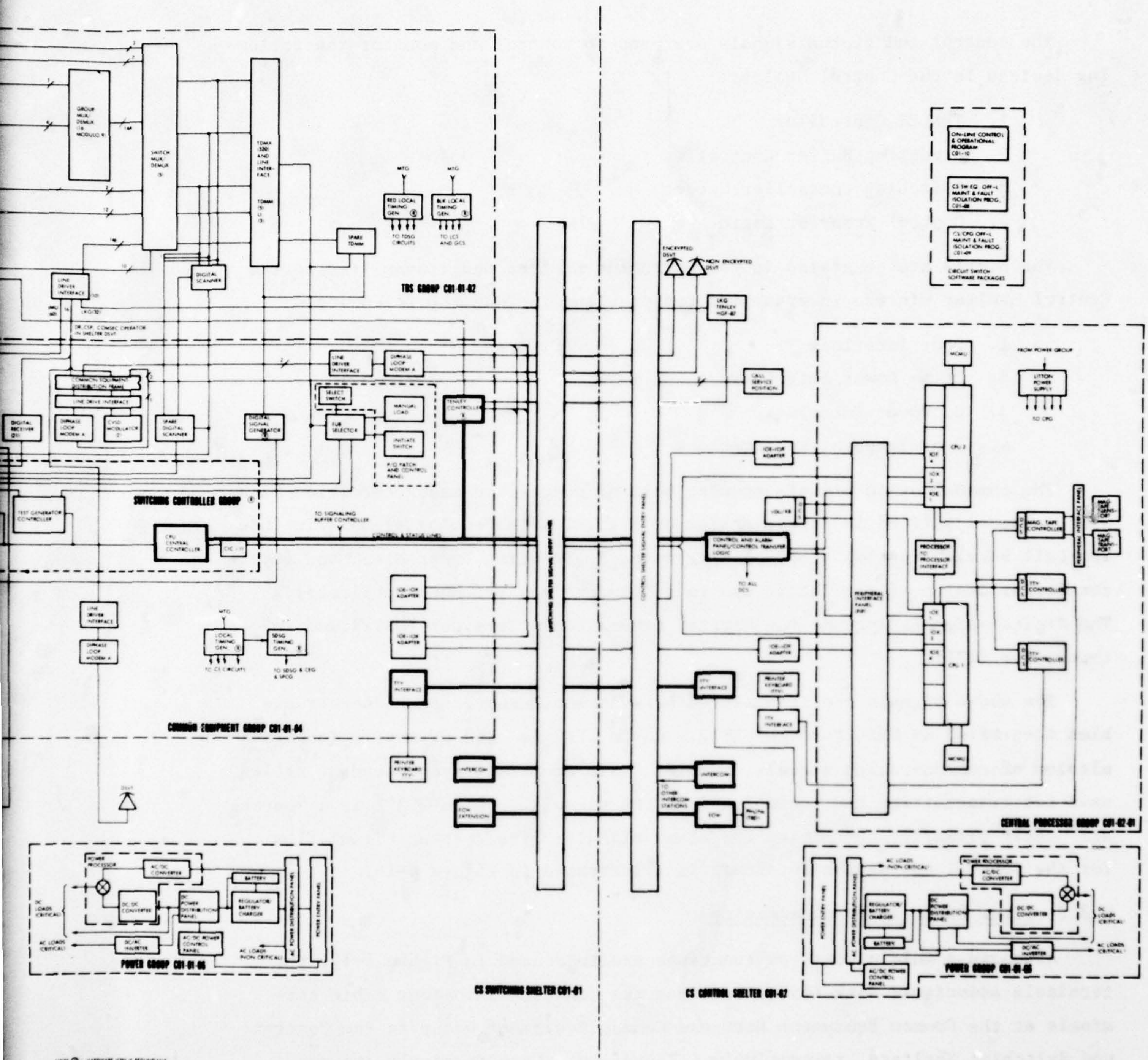


Figure 4-16. Circuit Switch Block Diagram

In addition, Cables WXX10 and 11 are redundant; it is recommended that only one cable (i.e., WXX10) be implemented to minimize cost and provide a basis for comparison. The resulting interconnectivity is illustrated in Figure 4-17, indicating that this multiplicity of signals be accommodated over a single pair of optical fibers. This multiplexing is achievable due to the low frequencies of each of the various channels as described in a following subsection.

4.3.3 Physical Interfaces

The C/S fiber optic link is connected to the Common Equipment Nest and Common Equipment Group as indicated by points C and C' in Figure 4-18.

Connections at point C will be made via three 52-pin MS connectors. The signals associated with point C include six full-duplex digital and analog voice channels on one connector, 26 dc control channels (including a station clock) on a second connector, and analog voice and dc status channels on a third connector. The signal names for each of the resulting 108 pins are listed in Appendix C, Section 1.

Connections at point C' will also be made via three 52-pin MS connectors. The relationship between signal names and physical pin locations for these connectors must be identical to that for the equivalent connectors at point C.

4.3.4 Electrical Interfaces

All channels of the sub-link must be transparent to signal flow; therefore, the electrical characteristics of the control shelter and switching shelter interfaces are identical.

The signals to be transmitted across these interfaces are as follows:

a. communications signals
b. alarm signals
c. control and status signals.

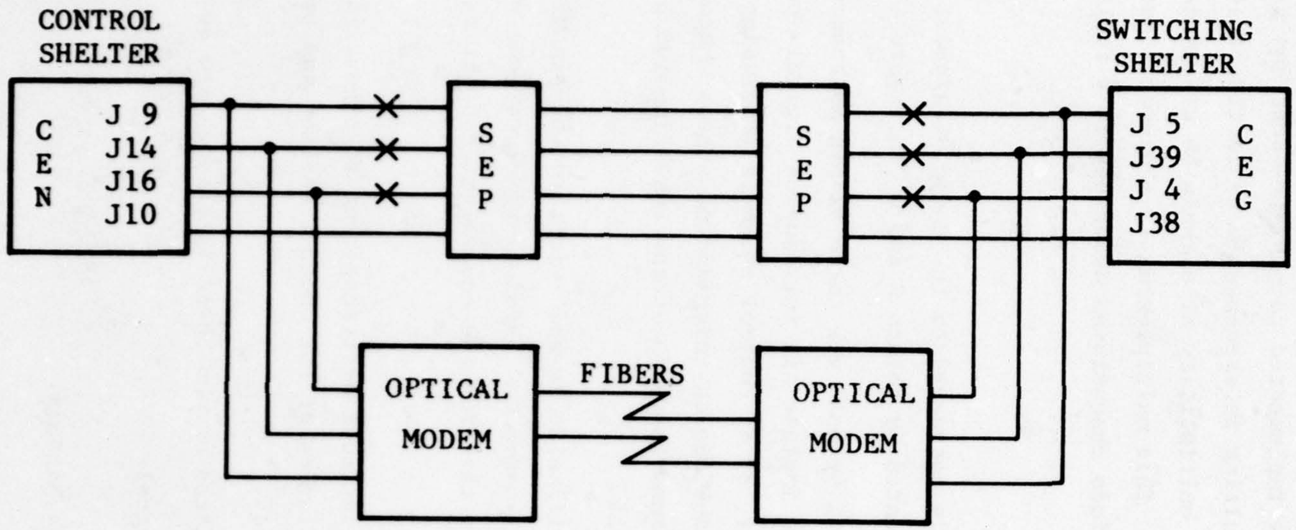


Figure 4-17. Optical Interface for C/S Link

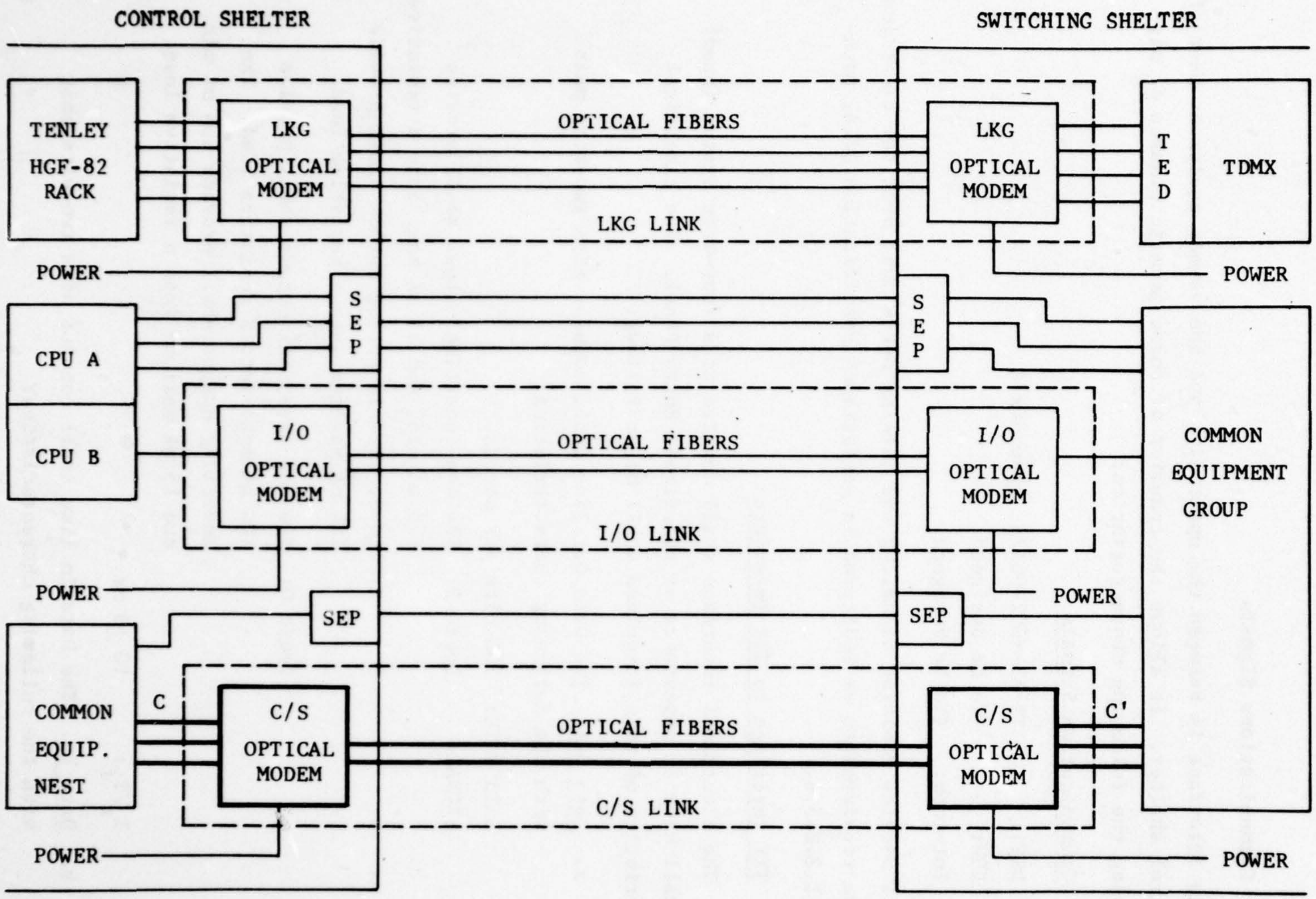


Figure 4-18. Block Diagram

4.3.4.1 Communications Signals

This interface is between the optic link and the common equipment nest of the control shelter. It allows the transfer of three generic classes of signals having the following characteristics:

Communication Signals

DSVT:	TT-A3-9002-0017A, Appendix A
EOW:	(To be designed)
Intercom:	(To be designed)

Call Service Position signaling and talking ports must meet the electrical interface requirements as indicated in performance specification C01A, paragraph 3.1.2.2.5.4.

TTY Interface to TTY Interface

The electrical interface shall consist of a four-wire system (quad) which shall have an appearance at the Signal Entry Panel. The electrical characteristics of this interface shall be as follows:

a. Data Out. The Data Out line shall consist of a two-wire pair with the following characteristics:

DATA RATE:	300 bits per second	
SIGNAL:	Logic 1:	The non-inverting output shall provide 6.5 mA min. and 15 mA max. into a resistive load. The inverting output shall provide 100 mA maximum into a resistive load.
	Logic 0:	The non-inverting output shall provide 100 mA max. into a resistive load. The inverting output shall provide 6.5 mA min. and 15 mA maximum into a resistive load.
T_r/T_f:	10 ± 5 ns	

b. Data In. The Data In line shall consist of a two-wire pair with the following characteristics:

FREQUENCY: 300 bits/second

SIGNAL: Logic 1: 0.25 VDC min. to 5.0 VDC maximum.

Logic 0: -0.025 VDC max. to -5.0 VDC minimum.

T_r/T_f: 10 $\pm$5 ns

4.3.4.2 Alarm Signals

These signals shall assume the active state upon the occurance of an operational failure and shall exhibit the following characteristics:

Active: Open circuit

Inactive: Closed circuit

4.3.4.3 Control and Status Signals

Interface logic for these signals consists of balanced differential driver/receiver pairs having the same electrical characteristics as those described in sub-section 4.

4.3.5 Functional Requirements

Functionally, the individual control, status, alarms, and digital and analog voice channels will be time-multiplexed for transmission via optical fibers from one shelter to the other.

Except for the synchronization necessary to maintain physical reference for each of the channels, there are no critical timing requirements to be met.

APPENDICES

Appendices A, B, and C contain lists of the signal names of the pins at interfacing connectors for the intershelter fiber optic application. They are intended for use by the feasibility development contractor and are not essential for estimating purposes. The notes referenced in these appendices are listed on the following page.

Appendix D is an extract from the AN/TTC-39 System Specification describing the Digital Transmission and Synchronization plans.

Appendix E is an excerpt from the AN/TTC-39 Control Processor Specification (Litton) describing the Input/Output Organization, functions, and characteristics.

Appendix F is a summary of the characteristics of all systems and components that interface with the AN/TTC-39.

NOTES TO APPENDICES A, B, AND C

1. Signal Convention relates to LKG. A positive voltage on the higher numbered signal pin, relative to the corresponding lower numbered pin, is a logic true, or one, signal.

2. A means to accommodate wire size AWG #28 into a size #22 contact pin must be provided.

3. Ground the outer shield(s) circumferentially to the backshell at P1 and/or P2 end(s), as applicable.

4. Unused pair(s) shall be dead-ended at each end, as applicable.

5. Cable type SM-A-838161/78, pairs, 90Ω consist of 3 individually shielded and jacketed cable types SM-A-838161/26 Pairs, 90Ω joined together at the P1 end with 3 separate legs terminating at P2, P3, and P4 respectively.

6. Ground the outer shield to pins 2, 4, 8, 14, 20, 26, 32, 36, 42, 48, 54, 60, 64, and 66 at P1 and/or P2 ends as applicable.

7. Cable type (SM-A-838161/ZΩ) shall contain 26 pairs of #28 AWG stranded wire and an overall shield, unless otherwise indicated.

8. Terminate leads from P2 pins 27 and 29 in P1 pin 23.

9. Form dead-end terminations on cable pairs at P1 end that eminate from P2 pins (31,34), (33,35), (37,38), (39,40), (41,44), (43,46), (45,47), (49,50), (51,52), (53,55), (56,57), (58,59), and (61,62).

10. Not used.

11. Signal convention relates to LCSP, Intercom, DSVT, and EOW circuit switch located equipments. That is, 'DSVT' "Enc. XMIT." is defined as XMIT from DSVT.

12. CAUTION:
The referenced P1 and P2 'J' receptacle number (URD) unit reference designations are for tracking purposes ONLY. Actual URD's are not available at this time (June 6, 1975).

13. Signal convention relates to CBU's, Receiver Sender, and/or IMU's. That is, "CBU XMIT" is defined as XMIT from CBU.

APPENDIX A

CONNECTOR INTERFACES FOR LKG SIGNALS

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX1	CABLE TYPE/NO. SM-A-838161/90	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P30	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P4	LKG 1R, XMT A,	P29	LKG 7R	P59	LKG 14R
	PLAIN OUT, PTR	P28		P58	
P3	LKG 1R, RETURN	P27		P57	
P2	LKG 1R, RCV A,	P26		P56	
	PLAIN IN, PTT				
P1	LKG 1R, RETURN	P34	LKG 8R	P63	LKG 15R
		P33		P62	
P8	LKG 2R	P31		P61	
P7		P30		P60	
P6					
P5		P38	LKG 9R	P67	LKG 16R
		P37		P66	
P13	LKG 3R	P36		P65	
P12		P35		P64	
P10					
P9		P42	LKG 10R	P71	LKG 17R
		P41		P70	
P17	LKG 4R	P40		P69	
P16		P39		P68	
P15					
P14		P46	LKG 11R	P75	LKG 18R
		P45		P74	
P21	LKG 5R	P44		P73	
P20		P43		P72	
P19					
P18		P50	LKG 12R	P79	LKG 19R
		P49		P78	
P25	LKG 6R	P48		P77	
P24		P47		P76	
P23					
P22		P55	LKG 13R	P84	LKG 20R
		P54		P83	
		P53		P81	
		P52		P80	

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FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX1	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P30	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P88	LKG 21R	P115	LKG 28R		
P87		P114			
P86		P113			
P85		P112			
P92	LKG 22R	P119	LKG 29R		
P91		P118			
P90		P117			
P89		P116			
P96	LKG 23R	P123	LKG 30R		
P95		P122			
P94		P121			
P93		P120			
P100	LKG 24R	P127	LKG 31R		
P99		P126			
P98		P125			
P97		P124			
P104	LKG 25R	P132	LKG 32R		
P103		P131			
P102		P129			
P101		P128			
P107	LKG 26R				
P82					
P106					
P105					
P111	LKG 27R				
P110					
P109					
P108					

NOTES	
Apply NOtes 1-5,12 Unused Pins: 11,32,51,130,133-155	PAGE 2 OF 2

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX2	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P31	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P4	LKG 1B, XMTA,	P29	LKG 7B	P59	LKG 14B
	CIPHER OUT,CTT	P28		P58	
P3	LKG 1B, RETURN	P27		P57	
P2	LKG 1B, RCV A,	P26		P56	
	CIPHER IN, CTR				
P1	LKG 1B, RETURN	P34	LKG 8B	P63	LKG 15B
		P33		P62	
P8	LKG 2B	P31		P61	
P7		P30		P60	
P6					
P5		P38	LKG 9B	P67	LKG 16B
		P37		P66	
P13	LKG 3B	P36		P65	
P12		P35		P64	
P10					
P9		P42	LKG 10B	P71	LKG 17B
		P41		P70	
P17	LKG 4B	P40		P69	
P16		P39		P68	
P15					
P14		P46	LKG 11B	P75	LKG 18B
		P45		P74	
P21	LKG 5B	P44		P73	
P20		P43		P72	
P19					
P18		P50	LKG 12B	P79	LKG 19B
		P49		P78	
P25	LKG 6B	P48		P77	
P24		P47		P76	
P23					
P22		P55	LKG 13B	P84	LKG 20B
		P54		P83	
		P53		P81	
		P52		P80	

NOTES	PAGE 1 OF 2

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FIBER OPTICS APPLICATION STUDY.(U)
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UNCLASSIFIED NL

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DATE
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11-78
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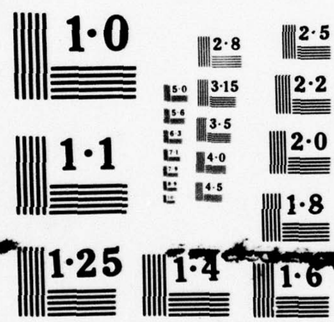

NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX2	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P31	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P88	LKG 21B	P115	LKG 28B		
P87		P114			
P86		P113			
P85		P112			
P92	LKG 22B	P119	LKG 29B		
P91		P118			
P90		P117			
P89		P116			
P96	LKG 23B	P123	LKG 30B		
P95		P122			
P94		P121			
P93		P120			
P100	LKG 24B	P127	LKG 31B		
P99		P126			
P98		P125			
P97		P124			
P104	LKG 25B	P132	LKG 32B		
P103		P131			
P102		P129			
P101		P128			
P107	LKG 26B				
P82					
P106					
P105					
P111	LKG 27B				
P110					
P109					
P108					

NOTES	Apply notes 1-5, 12 Unused Pins: 11,32,51,130,133-155	PAGE 2 OF 2

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX3	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P32	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P4	LKG 33R, XMT A,	P29	LKG 39R	P59	LKG 46R
	PLAIN OUT, PTR	P28		P58	
P3	LKG 33R, RETURN	P27		P57	
P2	LKG 33R, RCV A,	P26		P56	
	PLAIN IN, PTT				
P1	LKG 33R, RETURN	P34	LKG 40R	P63	LKG 47R
		P33		P62	
P8	LKG 34R,	P31		P61	
P7		P30		P60	
P6					
P5		P38	LKG 41R	P67	LKG 48R
		P37		P66	
P13	LKG 35R	P36		P65	
P12		P35		P64	
P10					
P9		P42	LKG 42R	P71	LKG 49R
		P41		P70	
P17	LKG 36R	P40		P69	
P16		P39		P68	
P15					
P14		P46	LKG 43R	P75	LKG 50R
		P45		P74	
P21	LKG 37R	P44		P73	
P20		P43		P72	
P19					
P18		P50	LKG 44R	P79	LKG 51R
		P49		P78	
P25	LKG 38R	P48		P77	
P24		P47		P76	
P23					
P22		P55	LKG 45R	P84	LKG 52R
		P54		P83	
		P53		P81	
		P52		P80	

NOTES	Apply Notes 1-5, 12 Unused Pins: 11,32,51,130,133-155	PAGE 1 OF 2

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER		APPENDIX A SECTION 1
CABLE DESIG. NO. WXX3	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P32	CONNECTOR PART NO. M81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P88	LKG 53R	P115	LKG 60R		
P87		P114			
P86		P113			
P85		P112			
P92	LKG 54R	P119	LKG 61R		
P91		P118			
P90		P117			
P89		P116			
P96	LKG 55R	P123	LKG 62R		
P95		P122			
P94		P121			
P93		P120			
P100	LKG 56R	P127	LKG 63R		
P99		P126			
P98		P125			
P97		P124			
P104	LKG 57R	P132	LKG 64R		
P103		P131			
P102		P129			
P101		P128			
P107	LKG 58R				
P82					
P106					
P105					
P111	LKG 59R				
P110					
P109					
P108					

NOTES		PAGE 2 OF 2
	Apply notes 1-5, 12 Unused pins: 11,32,51,130,133-155	

FUNCTIONAL INTERFACE		APPENDIX A
LKG - CONTROL SHELTER		SECTION 1
CABLE DESIG. NO. WXX4	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 64 STP
CONNECTOR DESIG. NO. P33	CONNECTOR PART NO. H81511/26EJ01S	CONNECTOR LOCATION TENLEY HGF-82 RACK

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P4	LKG 33B, XMTA,	P29	LKG 39B	P59	LKG 46B
	CIPHER OUT, CTT	P28		P58	
P3	LKG 33B, RETURN	P27		P57	
P2	LKG 88B, RCV A	P26		P56	
	CIPHER IN, CTR				
P1	LKG 33B, RETURN	P34	LKG 40B	P63	LKG 47B
		P33		P62	
P8	LKG 34B	P31		P61	
P7		P30		P60	
P6					
P5		P38	LKG 41B	P67	LKG 48B
		P37		P66	
P13	LKG 35B	P36		P65	
P12		P35		P64	
P10					
P9		P42	LKG 42B	P71	LKG 49B
		P41		P70	
P17	LKG 36B	P40		P69	
P16		P39		P68	
P15					
P14		P46	LKG 43B	P75	LKG 50B
		P45		P74	
P21	LKG 37B	P44		P73	
P20		P43		P72	
P19					
P18		P50	LKG 44B	P79	LKG 51B
		P49		P78	
P25	LKG 38B	P48		P77	
P24		P47		P76	
P23					
P22		P55	LKG 45B	P84	LKG 52B
		P54		P83	
		P53		P81	
		P52		P80	

NOTES Apply Notes 1-5, 12
Unused Pins: 11,32,51,130,133-155

PAGE 1 OF 2

FUNCTIONAL INTERFACE LKG - CONTROL SHELTER				APPENDIX A SECTION 1	
CABLE DESIG. NO. WXX4		CABLE TYPE/NO. SM-A-838161/90Ω		CABLE TYPE 64 STP	
CONNECTOR DESIG. NO. P33		CONNECTOR PART NO. M 81511/26EJ01S		CONNECTOR LOCATION TENLEY HGF-82 RACK	
PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P88	LKG 53B	P115	LKG 60B		
P87		P114			
P86		P113			
P85		P112			
P92	LKG 54B	P119	LKG 61B		
P91		P118			
P90		P117			
P89		P116			
P96	LKG 55B	P123	LKG 62B		
P95		P122			
P94		P121			
P93		P120			
P100	LKG 56B	P127	LKG 63B		
P99		P126			
P98		P125			
P97		P124			
P104	LKG 57B	P132	LKG 64B		
P103		P131			
P102		P129			
P101		P128			
P107	LKG 58B				
P82					
P106					
P105					
P111	LKG 59B				
P110					
P109					
P108					
NOTES	Apply notes 1-5, 12, 130, 133-155 Unused Pins: 11,32,51,130,133-155			PAGE 2 OF 2	

FUNCTIONAL INTERFACE LKG — SWITCHING SHELTER		APPENDIX A SECTION 2
CABLE DESIG. NO. —	CABLE TYPE/NO. RG-108 A/U	CABLE TYPE COXIAL
CONNECTOR DESIG. NO. —	CONNECTOR PART NO. SM-A-838684-	CONNECTOR LOCATION TED PATCH PANEL

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
R	RECEIVE CIPHER TEXT	R	TRANSMIT CIPHER TEXT		
S	↓	S	↓		
T		T			
R	RECEIVE CIPHER TEXT CLOCK	R	TRANSMIT CIPHER TEXT CLOCK		
S	↓	S	↓		
T		T			
R	RECEIVE PLAIN TEXT	R	TRANSMIT PLAIN TEXT		
S	↓	S	↓		
T		T			
R	RECEIVE PLAIN TEXT CLOCK	R	TRANSMIT PLAIN TEXT CLOCK		
S	↓	S	↓		
T		T			

NOTES R=RING, S=SHELL, T=TIP

PAGE 1 OF 1

APPENDIX B

CONNECTOR INTERFACES FOR I/O SIGNALS

FUNCTIONAL INTERFACE I/O - CONTROL SHELTER		APPENDIX B SECTION 1
CABLE DESIG. NO. WXX5	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P22	CONNECTOR PART NO. SM-C-811343	CONNECTOR LOCATION COMMON EQUIP. NEST

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	PARITY (odd)	P34	REQUEST 3	P57	CTL/TENLEY-B,
P1	Return	P31	Return		STATUS-B
				P58	Return
P6	INFORMATION 0	P35	4		
P5	Return	P33		P62	CTL/TENLEY-B,
					ENABLE
P10	1	P38	5		IOX/IOE-2C1
P7		P37		P61	Return
P12	2	P40	6	P65	CTL/TENLEY-B,
P9		P39			ENABLE
					IOX/IOE-2C2
P13	3	P44	7	P63	Return
P11		P41			
P16	4	P46	ENABLE		
P15		P43	Return		
P18	5	P47	COMMAND		
P17		P45	Return		
P22	6	P50	INDICATOR		
P29		P49	Return		
P24	7	P52	CTL/TENLEY-B,		
P21			SEND DATA		
		P51	Return		
P25	REQUEST 0				
P23	Return	P55	Spare 1		
		P53	Return		
P28	1				
P27		P57	CTL/TENLEY-B,		
			STATUS-A		
P30	2	P56	Return		
P29					

NOTES	Apply Notes 2,3,6,7	PAGE 1 OF 1

FUNCTIONAL INTERFACE I/O - CONTROL SHELTER		APPENDIX B SECTION 1
CABLE DESIG. NO. WXX7	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P24	CONNECTOR PART NO. MS3476E22-55P	CONNECTOR LOCATION PERIPHERAL INT. PANEL

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P-A	PARITY (odd)	P-b	REQUEST 3	P-BB	Spare 5
P-B	Return	P-c	Return	P-CC	Return
P-C	INFORMATION 0	P-d	4	P-DD	6
P-D	Return	P-e		P-EE	
P-E	1	P-f	5		
P-F		P-g			
P-G	2	P-h	6		
P-H		P-i			
P-J	3	P-j	7		
P-K		P-k			
P-L	4	P-m	ENABLE		
P-M		P-n	Return		
P-N	5	P-p	COMMAND		
P-P		P-q	Return		
P-R	6	P-r	INDICATOR		
P-S		P-s	Return		
P-T	7	P-t	Spare 1		
P-U		P-u	Return		
P-V	REQUEST 0	P-v	2		
P-W	Return	P-w			
P-X	1	P-x	3		
P-Y		P-y			
P-Z	2	P-z	4		
P-a		P-AA			

NOTES Apply Notes 2,3,7	PAGE 1 OF 1

FUNCTIONAL INTERFACE I/O - SWITCHING SHELTER		APPENDIX B SECTION 2
CABLE DESIG. NO. WX52	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-811343	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	PARITY (odd)	P34	REQUEST 3	P59	CTL/TENLEY-B, STATUS-B
P1	Return	P31	Return	P58	Return
P6	INFORMATION 0	P35	4	P62	CTL/TENLEY-B, ENABLE IOX/IOE-2C1
P5	Return	P33		P61	Return
P10	1	P38	5	P65	CTL/TENLEY-B, ENABLE IOX/IOE-2C2
P7		P37		P63	Return
P12	2	P40	6		
P9		P39			
P13	3	P44	7		
P11		P41			
P16	4	P46	ENABLE		
P15		P43	Return		
P18	5	P47	COMMAND		
P17		P45	Return		
P22	6	P50	INDICATOR		
P19		P49	Return		
P24	7	P52	CTL/TENLEY-B, SEND DATA		
P21		P51	Return		
P25	REQUEST 0	P55	Spare		
P23	Return	P53	Return		
P28	1	P57	CTL/TENLEY-B, STATUS-A		
P27		P56	Return		
P30	2				
P29					

NOTES Apply Notes: 2,3,6,7, & 12	PAGE 1 OF 1

FUNCTIONAL INTERFACE I/O - SWITCHING SHELTER		APPENDIX B SECTION 2
CABLE DESIG. NO. WX54	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-811343	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	PARITY (odd)	P34	REQUEST 3	P62	Spare 5
P1	Return	P31	Return	P61	Return
P6	INFORMATION 0	P35	4	P65	6
P5	Return	P33		P63	
P10	1	P38	5		
P7		P37			
P12	2	P40	6		
P9		P39			
P13	3	P44	7		
P11		P41			
P16	4	P46	ENABLE		
P15		P43	Return		
P18	5	P47	COMMAND		
P17		P45	Return		
P22	6	P50	INDICATOR		
P19		P49	Return		
P24	7	P52	Spare 1		
P21		P51	Return		
P25	REQUEST 0	P55	2		
P23	Return	P53			
P28	1	P57	3		
P27		P56			
P30	2	P51	4		
P29		P58			

NOTES Apply Notes: 2,3,6,7, & 12

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APPENDIX C

CONNECTOR INTERFACES FOR C/S SIGNALS

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER		APPENDIX C SECTION 1
CABLE DESIG. NO. WXX9	CABLE TYPE/NO. SM-A-838161/90 Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P26	CONNECTOR PART NO. SM-C-81134-1	CONNECTOR LOCATION COMMON EQUIP. NEST

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	Spare 1	P30	DSVT-2, NON-ENC,	P55	DSVT, ENC, RCV
P1	Return		XMT	P53	Return
		P29	Return		
P6	2			P57	DSVT, ENC, XMT
P5		P34	DSVT-2,NON-ENC,	P56	Return
			RCV		
P10	3	P31	Return	P59	EOW, EXT, XMT
P7				P58	Return
		P35	Spare 12		
P12	4	P33	Return	P62	EOW, EXT, RCV
P9				P61	Return
		P38	LCSP, SIG, XMT		
P13	5	P37	Return	P65	LCSP, SIG, RCV
P11				P63	Return
		P40	INTERCOM-1		
P16	6	P39	Return		
P15					
		P44	-2		
P18	7	P41			
P17					
		P46	-3		
P22	8	P43			
P19					
		P47	Spare 13		
P24	9	P45	Return		
P21					
		P50	DSVT, NON-ENC,		
P25	10		RCV		
P23		P49	Return		
P28	11	P52	DSVT, NON-ENC,		
P27			XMT		
		P51	Return		

NOTES

Apply Notes: 2,3,6, 7 & 11

PAGE 1 OF 1

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER		APPENDIX C SECTION 1
CABLE DESIG. NO. WX10	CABLE TYPE/NO. SM-A-838161/90 Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P27	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. NEST

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	Spare 1	P24	CTL/SCG-A, STATUS A	P46	TENLEY CONT.A, DATA-IN
P1	Return	P21	Return	P43	Return
P6	CTL/SBC-A, CONTLR CONNTD	P25	CTL/SCG-A, STATUS B	P47	TENLEY CONT. A, SVC. REQ.
P5	Return	P23	Return	P45	Return
P10	CTL/SBC-A, STATUS A	P28	CTL/SCG-A, ENABLE IOX-1A	P50	TENLEY CONT. A, READY ACK
P7	Return	P27	Return	P49	Return
P12	CTL/SBC-A, STATUS B	P30	CTL/SCG-A ENABLE IOX-1B	P52	TENLEY CONT.A, DATA-OUT
P9	Return	P29	Return	P51	Return
P13	CTL/SBC-A, ENABLE IOX/IOE-1C	P34	CTL/SCG-A, DEVICES CONNECT	P55	TENLEY CONT.A PARITY ERROR-1
P11	Return	P31	Return	P53	Return
P16	CTL/SBC-A, ENABLE IOX/IOE-1C	P35	TENLEY CONT.A, ON LINE	P57	TENLEY CONT.A, PARITY ERROR-2
P15	Return	P33	Return	P56	Return
P18	CTL/SBC-A, CONTLR CONNECT	P38	TENLEY CONT.A, STATION CLOCK	P59	TENLEY CONT.A, OPERATING
P17	Return	P37	Return	P58	TENLEY CONT. A, COMMON ENABLE
P22	CTL/SCG-A DEVICES CONNECTED	P40	TENLEY CONT. A, READY	P62	TENLEY CONT.A, ALARM
P19	Return	P39	Return		
		P44	TENLEY CONT.A, SVC.REQ.ACK		
		P41	Return		

NOTES

Apply notes 2,3,6,7

PAGE 1 OF 2

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER		APPENDIX C SECTION 1
CABLE DESIG. NO. WX10	CABLE TYPE/NO. SM-A-838161/90 Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P27	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. NEST

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P61	TENLEY CONT.A, COMMON ENABLE				
P65	TENLEY CONT.A, LOOP DATA RATE CLOCK				
P63	Return				

NOTES

Apply Notes 2,3,6,7

PAGE 2 OF 2

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER		APPENDIX C SECTION 1
CABLE DESIG. NO. WX11	CABLE TYPE/NO. SM-A-838161/90 Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P28	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION Common Equip. Nest

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	Spare 1	P24	CTL/SCG-B,	P46	TENLEY CONT. B,
P1	Return		STATUS A		DATA-IN
		P21	Return	P43	Return
P6	CTL/SBC-B,				
	CONTLR CONNTD	P25	CTL/SCG-B,	P47	TENLEY CONT. B,
P5	Return		STATUS B		SVC REQ
		P23	Return	P45	Return
P10	CTL/SBC-B				
	STATUS A	P28	CTL/SCG-B,	P50	TENLEY CONT. B,
P7	Return		ENABLE IOX-2A		READY ACK
		P27	Return	P49	Return
P12	CTL/SBC-B,				
	STATUS B	P30	CTL/SCG-B,	P52	TENLEY CONT. B,
P9	Return		ENABLE IOX-2B		DATA-OUT
		P29	Return	P51	Return
P13	CTL/SBC-B,				
	ENABLE	P34	CTL/SCG-B,	P55	TENLEY CONT. B,
	IOX/IOE-2A1		DEVICES CONNECT		PARITY ERROR-1
P11	Return	P31	Return	P53	Return
P16	CTL/SBC-B,	P35	TENLEY CONT.B,	P57	TENLEY CONT. B,
	ENABLE		ON-LINE		PARITY ERROR-2
	IOX/IOE-2A2	P33	Return	P56	Return
P15	Return				
		P38	TENLEY CONT. B,	P57	TENLEY CONT.B,
P18	CTL/SBC-B,		STATION CLOCK		OPERATING
	CONTLR CONNECT	P37	Return		
P17	Return			P58	TENLEY CONT. B,
		P40	TENLEY CONT. B,		COMMON ENABLE
P22	CTL/SCG-B,		READY		
	DEVICES CONNTD	P39	Return	P62	TENLEY CONT. B,
P19	Return				ALARM
		P44	TENLEY CONT. B,		
			SVC REQ ACK	P61	TENLEY CONT. B,
		P41	Return		COMMON ENABLE

NOTES Apply Notes: 2,3,6,7	PAGE 1 OF 2

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER				APPENDIX C SECTION 1	
CABLE DESIG. NO. WX11		CABLE TYPE/NO. SM-A-838161/90 Ω		CABLE TYPE 26 TP	
CONNECTOR DESIG. NO. P28		CONNECTOR PART NO. SM-C-811341		CONNECTOR LOCATION Common Equip. Nest	
PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P65	TENLEY CONT. B, LOOP DATA RATE CLOCK				
P63	Return				
NOTES Apply Notes: 2,3,6,7				PAGE 2 OF 2	

FUNCTIONAL INTERFACE C/S - CONTROL SHELTER		APPENDIX C SECTION 1
CABLE DESIG. NO. WX12	CABLE TYPE/NO. SM-A-838161/90 Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P29	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. NEST

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3 P1	LCSP 1, XMT A Return	P34 P31	Spare 9 Return	P51	SS DOOR INTERLOCK COMMON ENABLE
P6 P5	LCSP 1, RCV A Return	P35 P33	10	P55 P53	TGM SYNC STATUS Return
P10 P7	LCSP 2, XMT A Return	P38 P37	11	P57	SS PRIME POWER INTERLOCK OPEN
P12 P9	LCSP 2, RCV A Return	P40	SS OVERTEMP INTERLOCK OPEN	P56	SS PRIME POWER, COMMON ENABLE
P13 P11	Spare 1 Return	P39	SS OVERTEMP COMMON ENABLE	P59	SS PRIME POWER INTERLOCK CLOSED
P16 P15	2	P44	SS OVERTEMP INTERLOCK CLOSED	P58	SS PRIME POWER, COMMON ENABLE
P18 P17	3	P41	SS OVERTEMP, COMMON ENABLE	P62	SS SUM POWER INTERLOCK OPEN
P22 P19	4	P46 P43	TTY, RCV A Return	P61	SS SUM POWER, COMMON ENABLE
P24 P21	5	P47 P45	TTY, XMT A Return	P65	SS SUM POWER INTERLOCK CLOSED
P25 P23	6	P50	SS DOOR INTERLOCK OPEN	P63	SS SUM POWER, COMMON ENABLE
P28 P27	7	P49	SS DOOR INTERLOCK COMMON ENABLE		
P30 P29	8	P52	SS DOOR INTERLOCK CLOSED		

NOTES Apply Notes 2,3,6,7, & 11	PAGE 1 OF 1

FUNCTIONAL INTERFACE C/S - SWITCHING SHELTER		APPENDIX C SECTION 2
CABLE DESIG. NO. WX56	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	Spare 1	P30	DSVT-2, NON-ENC, XMT	P55	DSVT, ENC, RCV
P1	Return	P29	Return	P53	Return
P6	2	P34	DSVT-2,NON-ENC, RCV	P57	DSVT, ENC, XMT
P5		P31	Return	P56	Return
P10	3	P35	Spare 12	P59	EOW, EXT, XMT
P7		P33	Return	P58	Return
P12	4	P38	LCSP, SIG, XMT	P62	EOW, EXT, RCV
P9		P37	Return	P61	Return
P13	5	P40	INTERCOM-1	P65	LCSP, SIG, RCV
P11		P39	Return	P63	Return
P16	6	P44	-2		
P15		P41			
P18	7	P46	-3		
P17		P43			
P22	8	P47	Spare 13		
P19		P45	Return		
P24	9	P50	DSVT, NON-ENC, RCV		
P21		P49	Return		
P25	10	P52	DSVT, NON-ENC, XMT		
P23		P51	Return		
P28	11				
P27					

NOTES

Apply Notes: 2,3,6,11, & 12

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FUNCTIONAL INTERFACE C/S - SWITCHING SHELTER		APPENDIX C SECTION 2
CABLE DESIG. NO. WX57	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME
P3	Spare 1
P1	Return
P6	CTL/SBC-A, CONTLR CONNTD
P5	Return
P10	CTL/SBC-A, STATUS A
P7	Return
P12	CTL/SBC-A, STATUS B
P9	Return
P13	CTL/SBC-A, ENABLE IOX/IOE-1C
P11	Return
P16	CTL/SBC-A, ENABLE IOX/IOE-1C
P15	Return
P18	CTL/SBC-A, CONTLR CONNECT
P17	Return
P22	CTL/SCG-A DEVICES CONNECTED
P19	Return

PIN NO.	SIGNAL NAME
P24	CTL/SCG-A, STATUS A
P21	Return
P25	CTL/SCG-A, STATUS B
P23	Return
P28	CTL/SCG-A, ENABLE IOX-1A
P27	Return
P30	CTL/SCG-A ENABLE IOX-1B
P29	Return
P34	CTL/SCG-A, DEVICES CONNECT
P31	Return
P35	TENLEY CONT.A, ON LINE
P33	Return
P38	TENLEY CONT.A, STATION CLOCK
P37	Return
P40	TENLEY CONT. A, READY
P39	Return
P44	TENLEY CONT.A, SVC.REQ.ACK
P41	Return

PIN NO.	SIGNAL NAME
P46	TENLEY CONT.A, DATA-IN
P43	Return
P47	TENLEY CONT. A, SVC. REQ.
P45	Return
P50	TENLEY CONT. A, READY ACK
P49	Return
P52	TENLEY CONT.A, DATA-OUT
P51	Return
P55	TENLEY CONT.A PARITY ERROR-1
P53	Return
P57	TENLEY CONT.A, PARITY ERROR-2
P56	Return
P59	TENLEY CONT.A, OPERATING
P58	TENLEY CONT. A, COMMON ENABLE
P62	TENLEY CONT.A, ALARM

NOTES	
Apply Notes: 2,3,6,7, & 12	PAGE 1 OF 2

FUNCTIONAL INTERFACE				APPENDIX C	
C/S - SWITCHING SHELTER				SECTION 2	
CABLE DESIG. NO. WX57		CABLE TYPE/NO. SM-A-838161/90Ω		CABLE TYPE 26 TP	
CONNECTOR DESIG. NO. P2		CONNECTOR PART NO. SM-C-811341		CONNECTOR LOCATION COMMON EQUIP. GROUP	
PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P61	TENLEY CONT.A, COMMON ENABLE				
P65	TENLEY CONT.A, LOOP DATA RATE CLOCK				
P63	Return				
NOTES Apply notes: 2,3,6,7,& 12				PAGE 2 OF 2	

FUNCTIONAL INTERFACE C/S - SWITCHING CHELTER		APPENDIX C SECTION 2
CABLE DESIG. NO. WX 58	CABLE TYPE/NO. 5M-A-838161/90Ω	CABLE TYPE 26TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-811341	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3	Spare 1	P24	CTL/SCG-B,	P46	TENLEY CONT. B,
P1	Return		STATUS A		DATA-IN
		P21	Return	P43	Return
P6	CTL/SBC-B,				
	CONTLR CONNTD	P25	CTL/SCG-B,	P47	TENLEY CONT. B,
P5	Return		STATUS B		SVC REQ
		P23	Return	P45	Return
P10	CTL/SBC-B				
	STATUS A	P28	CTL/SCG-B,	P50	TENLEY CONT. B,
P7	Return		ENABLE IOX-2A		READY ACK
		P27	Return	P49	Return
P12	CTL/SBC-B,				
	STATUS B	P30	CTL/SCG-B,	P52	TENLEY CONT. B,
P9	Return		ENABLE IOX-2B		DATA-OUT
		P29	Return	P51	Return
P13	CTL/SBC-B,				
	ENABLE	P34	CTL/SCG-B,	P55	TENLEY CONT. B,
	IOX/IOE-2A1		DEVICES CONNECT		PARITY ERROR-1
P11	Return	P31	Return	P53	Return
P16	CTL/SBC-B,	P35	TENLEY CONT.B,	P57	TENLEY CONT. B,
	ENABLE		ON-LINE		PARITY ERROR-2
	IOX/IOE-2A2	P33	Return	P56	Return
P15	Return				
		P38	TENLEY CONT. B,	P57	TENLEY CONT.B,
P18	CTL/SBC-B,		STATION CLOCK		OPERATING
	CONTLR CONNECT	P37	Return		
P17	Return			P58	TENLEY CONT. B,
		P40	TENLEY CONT. B,		COMMON ENABLE
P22	CTL/SCG-B,		READY		
	DEVICES CONNTD	P39	Return	P62	TENLEY CONT. B,
P19	Return				ALARM
		P44	TENLEY CONT. B,		
			SVC REQ ACK	P61	TENLEY CONT. B,
		P41	Return		COMMON ENABLE

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Apply Notes: 2,3,6,7,& 12	

FUNCTIONAL INTERFACE C/S - SWITCHING SHELTER				APPENDIX C SECTION 2	
CABLE DESIG. NO. WX58		CABLE TYPE/NO. 5M-A-838161/90Ω		CABLE TYPE 26 TP	
CONNECTOR DESIG. NO. P2		CONNECTOR PART NO. SM-C-811341		CONNECTOR LOCATION COMMON EQUIP.GROUP	
PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P65	TENLEY CONT. B, LOOP DATA RATE CLOCK				
P63	Return				
NOTES Apply Notes: 2,3,6,7, & 12				PAGE 2 OF 2	

FUNCTIONAL INTERFACE C/S - SWITCHING SHELTER		APPENDIX C SECTION 2
CABLE DESIG. NO. WX59	CABLE TYPE/NO. SM-A-838161/90Ω	CABLE TYPE 26 TP
CONNECTOR DESIG. NO. P2	CONNECTOR PART NO. SM-C-81134-1	CONNECTOR LOCATION COMMON EQUIP. GROUP

PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME	PIN NO.	SIGNAL NAME
P3 P1	LCSP 1, XMT A Return	P34 P31	Spare 9 Return	P51	SS DOOR INTERLOCK COMMON ENABLE
P6 P5	LCSP 1, RCV A Return	P35 P33	10	P55 P53	TGM SYNC STATUS Return
P10 P7	LCSP 2, XMT A Return	P38 P37	11	P57	SS PRIME POWER INTERLOCK OPEN
P12 P9	LCSP 2, RCV A Return	P40	SS OVERTEMP INTERLOCK OPEN	P56	SS PRIME POWER, COMMON ENABLE
P13 P11	Spare 1 Return	P39	SS OVERTEMP COMMON ENABLE	P59	SS PRIME POWER INTERLOCK CLOSED
P16 P15	2	P44	SS OVERTEMP INTERLOCK CLOSED	P58	SS PRIME POWER, COMMON ENABLE
P18 P17	3	P41	SS OVERTEMP, COMMON ENABLE	P62	SS SUM POWER INTERLOCK OPEN
P22 P19	4	P46 P43	TTY, RCV A Return	P61	SS SUM POWER, COMMON ENABLE
P24 P21	5	P47 P45	TTY, XMT A Return	P65	SS SUM POWER INTERLOCK CLOSED
P25 P23	6	P50	SS DOOR INTERLOCK OPEN	P63	SS SUM POWER, COMMON ENABLE
P28 P27	7	P49	SS DOOR INTERLOCK COMMON ENABLE		
P30 P29	8	P52	SS DOOR INTERLOCK CLOSED		

NOTES

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APPENDIX D

DIGITAL TRANSMISSION GROUP SYNCHRONIZATION PLAN

NOTE

The contents of this Appendix is an excerpt from the AN/TTC-39 System Specification. The original paragraph, figure, and table numbering has been retained.

3.2 System Considerations

The following subsections shall define the functional performance characteristics and requirements for data transmission over a link which interfaces with an AN/TTC-39 Circuit Switch.

3.2.1 Digital Transmission Group (DTG)

A DTG shall consist of a collection of individual digital loop channels, channel groups (subgroups of the DTG) or any combination thereof which has been time-multiplexed into a single bit stream for transmissicn over a communications link. A subgroup shall be defined as a collection of channels used for trunking (trunk group) or for subscriber loops (loop group). All trunk groups and loop groups shall contain an overhead channel used for framing, common channel signaling, and/or SYSCON. The first channel in a DTG and each subgroup shall always be designated as an overhead channel. The first DTG channel may be used as the overhead channel of a subgroup as well as the overhead channel of the DTG. The number of overhead channels within a DTG, excluding the first channel of the DTG, shall not exceed the number of trunk groups and loop groups in that DTG. The number of signaling overhead channels shall be limited by the number of TSB's in the circuit switch.

3.2.2 Modularity

The group modularities of DTG's shall be 8, 9, 16, 18, 32, 36, 48, 64, 72, 128 and 144 channels per group. The 128 and 144 group modularities shall be defined as Super Groups.

3.2.3 Transmission Rates

The baseband information transmission rate of a DTG shall be the appropriate multiple, based on the group modularity, of the individual channel data transmission rate (16 kb/s or 32 kb/s); see Table 3.2-1. The modulated transmission rate shall be dependent upon the type of modulation used. For diphase modulation, the modulated transmission rate shall be

TABLE 3.2-1

DTG BASEBAND INFORMATION RATES

CHANNELS PER DTG	FOR 16 kb/s PER CHANNEL DTG RATE kb/s	FOR 32 kb/s PER CHANNEL DTG RATE kb/s
8	128	256
9	144	288
16	256	512
18	288	576
32	512	1024
36	576	1152
48	768	1536
64	1024	2048
72	1152	2304
128	2048	4096
144	2304	4608

identical to the baseband information transmission rate. For dipulse modulation, the modulated transmission rate shall always be 2304 kb/s. The use of dipulse transmission shall be limited to group modularities of seventy-two channels or less at the 32-kb/s channel rate.

3.2.4 Modulation

Two types of modulation, diphase, shall be used on communication links which interface with an AN/TTC-39 DTG.

3.2.4.1 Diphase Modulation

Conditional digital diphase, a form of differentially coherent PSK modulation, shall be employed for transmission of digital traffic on communication links between connecting nodes.

All transmitted digital diphase data shall be conditioned; that is, the binary information shall be contained in the transmission between voltage states rather than the voltage level state itself.

Within the TDSG subsystem, binary information shall be carried as a baseband signal; that is, the signal is recognized by the level of the waveform voltage. A "one" or "bit present" shall be indicated by a low signal level (approximately zero volts) and a "zero" or "no bit present" shall be given by a high-voltage level, (approximately five volts). Baseband data shall be conditioned by causing the baseband signal level to change on a "one" bit and to not change on a "zero" bit. For example, the baseband signal of 0101001100 shall be converted to the conditioned signal 0110001000. This signal shall then be modulo-2 added to a square wave at the transmission rate in synchronism with the original timing pulses to produce a conditioned digital diphase modulated signal for transmission over a communications link.

3.2.4.2 Dipulse Modulation

Dipulse modulation shall be employed for transmission over cable to the PCM-type radio equipment currently in Government inventory.

In dipulse transmission a half-width (half-bit) pulse shall be sent when a logic "one" data bit is present at baseband and no signal shall be sent for a logic "zero" at baseband. The half-width logic "one" pulse shall extend above and below the reference dc level found on the cable as shown in Figure 3.2-1.

3.2.5 Transmission Media

Transmission links interfacing the DTG shall consist of CX-11230 coaxial cable and Government-furnished radio and multiplexing equipment. The coaxial cable and its characteristics shall be as specified in Military Specification MIL-C-55583A.

The noise environment over any established path containing no more than one radio link shall be such that the received bit stream will contain bit errors resulting in, as a maximum, 20% bit error bursts interspersed with a randomly distributed 10^{-3} bit error occurrence. These error bursts shall have a maximum duty cycle of 5% and a burst rate from 1.0 to 20 Hz. For the purposes of statistical analysis in the determination of signaling message throughput, call completion time, processor work load, and call misrouting requirements, the distribution of the burst occurrence in the 1.0 to 20.0 Hz range shall be assumed to occur uniformly with equal probability (i.e, random distribution).

3.2.6 Repeaters

It is expected that both diphase and dipulse transmission links shall contain repeaters. For this eventuality a current loop-around capability shall be provided in the DTG equipment for all transmission group modularities up to and including

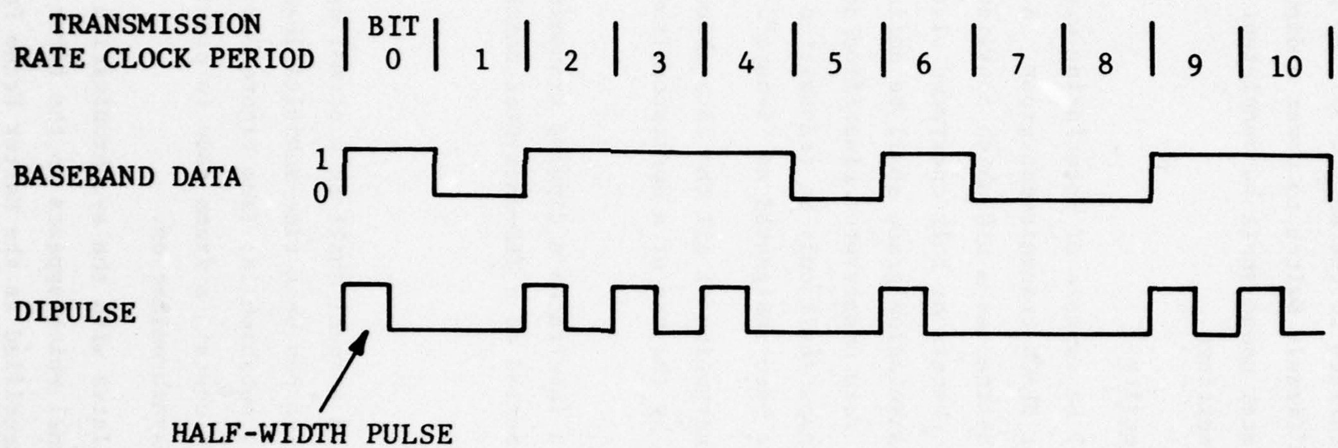


Figure 3.2-1. - Dipulse Waveform and Timing

seventy-two channels. Transmission links containing DTG's with 128 or 144 group modularities shall not require the use of a repeater for interface to the AN/TTC-39. No power shall be provided by the Circuit Switch to power a dipulse or a diphase repeater. Repeater usage shall be consistent with the DTG modem distance settings.

3.2.7 Transmission Security

A DTG shall be capable of interfacing with a communications link as a RED or BLACK transmission group. A BLACK transmission group shall be defined as a DTG which contains unencrypted, unclassified data chanels or bulk encrypted classified data channels. A RED transmission group shall be defined as a DTG which contains one or more unencrypted classified data channels. RED transmission groups shall only be transmitted over transmission links which have been designated as "Secure".

The bulk encryption of all the data channels in a DTG shall be accomplished by the use of a dedicated Trunk Encryption Device (TED).

A DTG which interfaces a dipulse transmission link shall always be implemented as a TED-encrypted BLACK Transmission Group.

3.2.8 Overhead Channel

The overhead channel shall be a normal data channel (32/16 kb/s) which has been time-submultiplexed to provide eight (4/2 kb/s) subchannels; (see Figure 3.2-2). The first subchannel shall contain a frame code to provide for DTG or subgroup frame synchronization.

When associated with the synchronization of a DTG, the framing subchannel which appears in the first channel of the DTG shall be identified as the Master Frame Position. The frame code for this framing subchannel shall be a repeating 1010 pattern. When associated with the synchronization of a subgroup in other than the first channel of a DTG, the frame code shall be a repeating 1100 pattern.

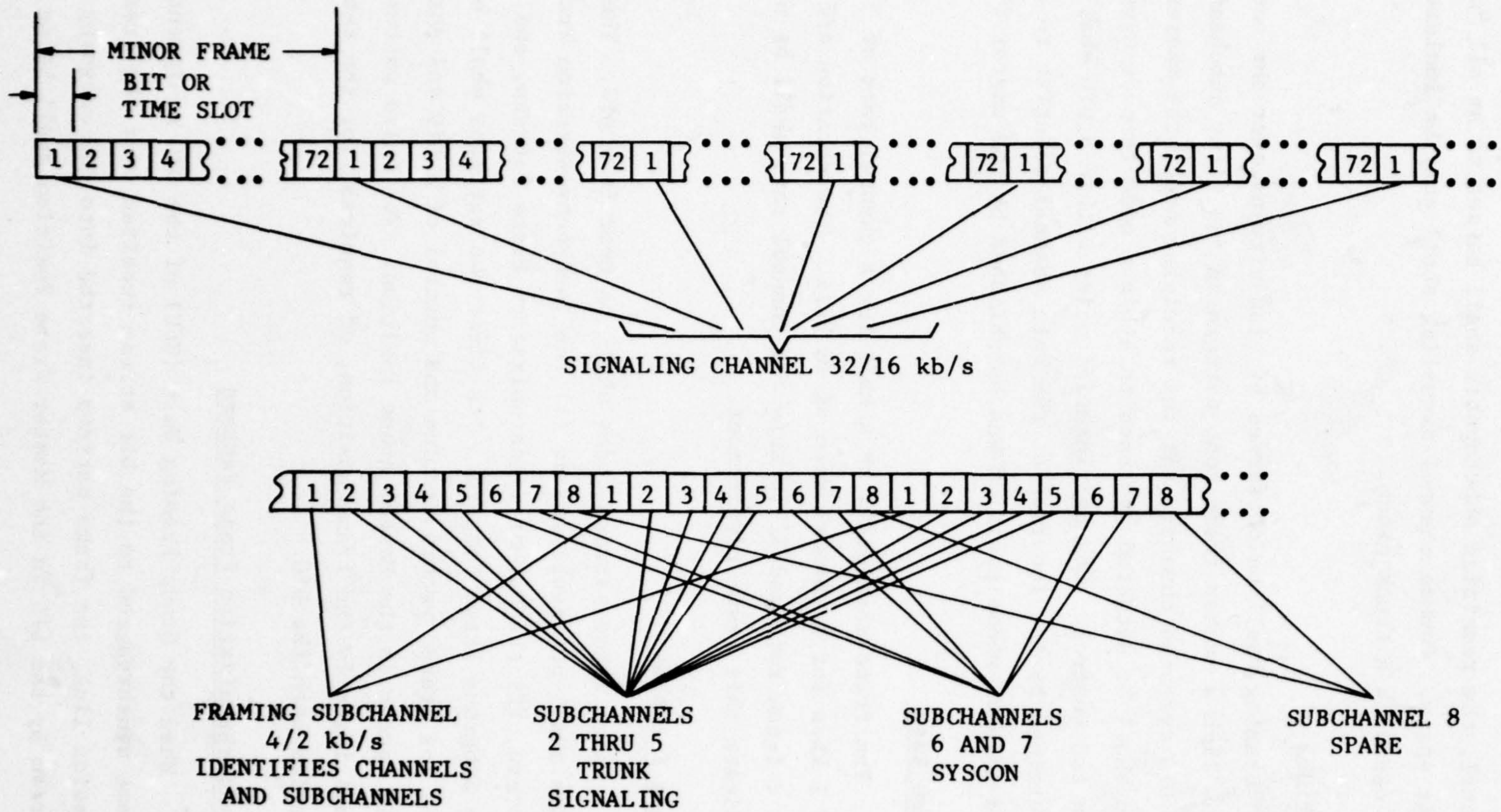


Figure 3.2-2. - DTG and Signaling Channel Format

Unless designated for implementation as a common signaling channel, the remaining subchannels shall be set to an all "ones" logic state. Common channel signaling shall only be implemented for use with a trunk group.

3.2.9 Framing

Framing shall be performed by transmitting over the communications link a master frame code pattern in the first subchannel of the DTG overhead channel. At the receiving node, the master frame code shall be detected and used to achieve node-to-node synchronization and control. Channel identification within a DTG shall be determined by the location of the data channel relative to the overhead channel whose position was established by the master frame code.

3.2.9.1 Frame Rate

The frame rate shall be 4 kb/s for a channel rate of 32 kb/s and 2 kb/s for a channel rate of 16 kb/s. The notation 4/2 kb/s for a frame rate and 32/16 kb/s for channel rate shall be used to indicate this frame requirement.

3.2.9.2 Frame Patterns

Three frame pattern codes shall be used in a DTG. These codes shall be identified as (1) the In-Synchronization Frame Pattern, (2) the Out-of-Synchronization Frame Pattern, and (3) the Subgroup Frame Pattern. The first two patterns shall be used for frame synchronization and control of a DTG and shall only appear in the Master Frame Position. The third pattern shall identify the frame position, if required, for the subgroups carried with the DTG.

3.2.9.2.1 In-Sunchronization Frame Pattern

When the Group Framing Unit (GFU) of the DTG equipment is frame synchronized to the bit stream received over the transmission link, the frame pattern inserted into the outgoing bit stream by the GFU in the Master Frame Position shall be an

alternating one-zero pattern (1010) at the 4/2 kb/s rate. This frame pattern since it is the code normally transmitted and received shall be designated as the Master Frame Code.

3.2.9.2.2 <u>Out-of-Synchronization Frame Pattern</u>

When the GFU of the DTG equipment detects a loss of frame synchronization on the received link, the transmitted frame pattern returned to the interfacing mode shall be changed from the In-Synchronization Frame Pattern code to the Out-of-Synchronization Pattern Code. The Out-of-Synchronization Frame pattern code shall be a pattern of all "ones". Detection of this pattern at a receiving node shall be considered as a Request-for-Synchronization from the transmitting node.

3.2.9.2.3 <u>Subgroup Frame Pattern</u>

This frame pattern shall be used by external interfacing equipment to identify channel location within the associated subgroup. In the DTG, this repeating 1100 pattern shall be inserted into the outgoing overhead channel of each subgroup. For all trunk groups, the frame code pattern (1100) shall be generated and inserted into subchannel No. 1 of each overhead by the Trunk Signaling Buffer. For loop groups, the frame code pattern (1100) shall be generated by the Digital Signal Generator (DSG) and switched onto the overhead channel through the Time Division Matrix. The (DSG) signal shall be constructed such that the 1100 pattern will appear in subchannel No. 1 and an all "ones" pattern will appear in subchannels Nos. 2 through 8, inclusive. When the trunk group or loop group shares the overhead channel of a DTG, the Group Framing Unit (GFU) shall automatically suppress the repeating 1100 frame pattern and shall replace it with the alternating 1010 Master Frame code.

3.2.9.3 <u>Frame Alignment</u>

A minor frame shall be defined as being equivalent in time to a 32/16 kb/s bit period (33/15.5 μs) and shall contain the

number of channels designated by the modularity of the DTG. A major frame shall consist of eight minor frames with the first minor frame (designated as F1) containing the Master Frame Position (Index) as shown in Figure 3.2-3. All overhead channels used for trunk groups shall have subchannel No. 1 appear in the F1 minor frame in order to provide subchannel alignment with the Master Frame Position, see Figures 3.2-3 and 3.2-4. Each received DTG shall have its Master Frame Position (Index) aligned within the Group Framing Unit to the System Frame Reference to establish Major Frame Alignment of all received transmission group bit streams, see Figures 3.2-3 and 3.2-5.

3.2.9.4 Frame Synchronization

The Digital Transmission Group (DTG) equipment shall be capable of achieving end-around synchronization on all transmission links (including those that are TED encrypted) using automatic or manual procedures. The performance, operational requirements, and procedures for automatic end-around synchronization of a DTG shall be as specified in SR 204, Revision A, Digital Transmission Group Synchronization.

3.2.9.5 Channel Rotation

Channels within a minor frame shall always be associated with a specific time slot. No change in position or rotation relative to the Master Frame Index shall be allowed.

3.2.10 Channel Assignment

The first channel (time slot) within a DTG minor frame shall always be assigned as the overhead channel which controls the DTG, see Figure 3.2-4. Any other channel time slot within the DTG minor frame can be assigned as a traffic channel or a subgroup overhead channel. Since the subgroup framing (suppressed frame) patterns are not detected, the assignment of all channels within a DTG minor frame shall be prearranged to insure that the time

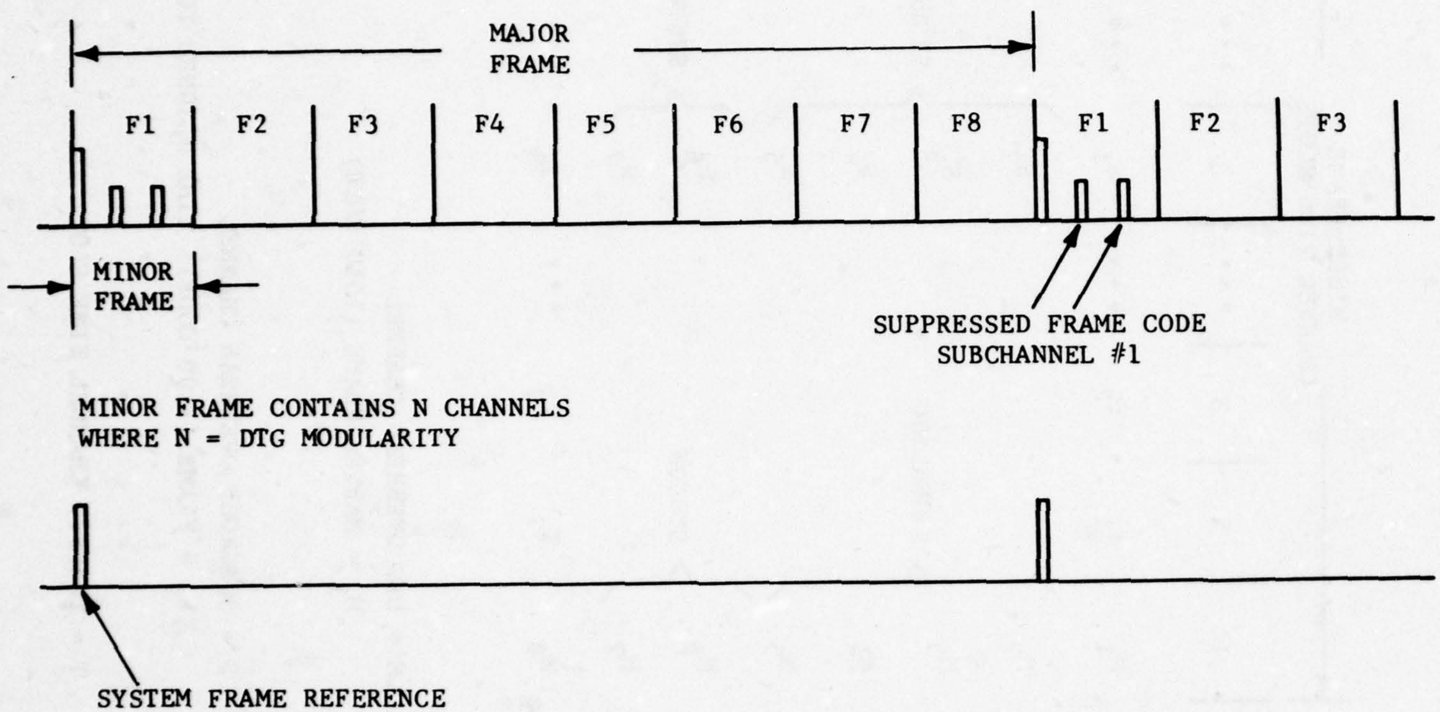
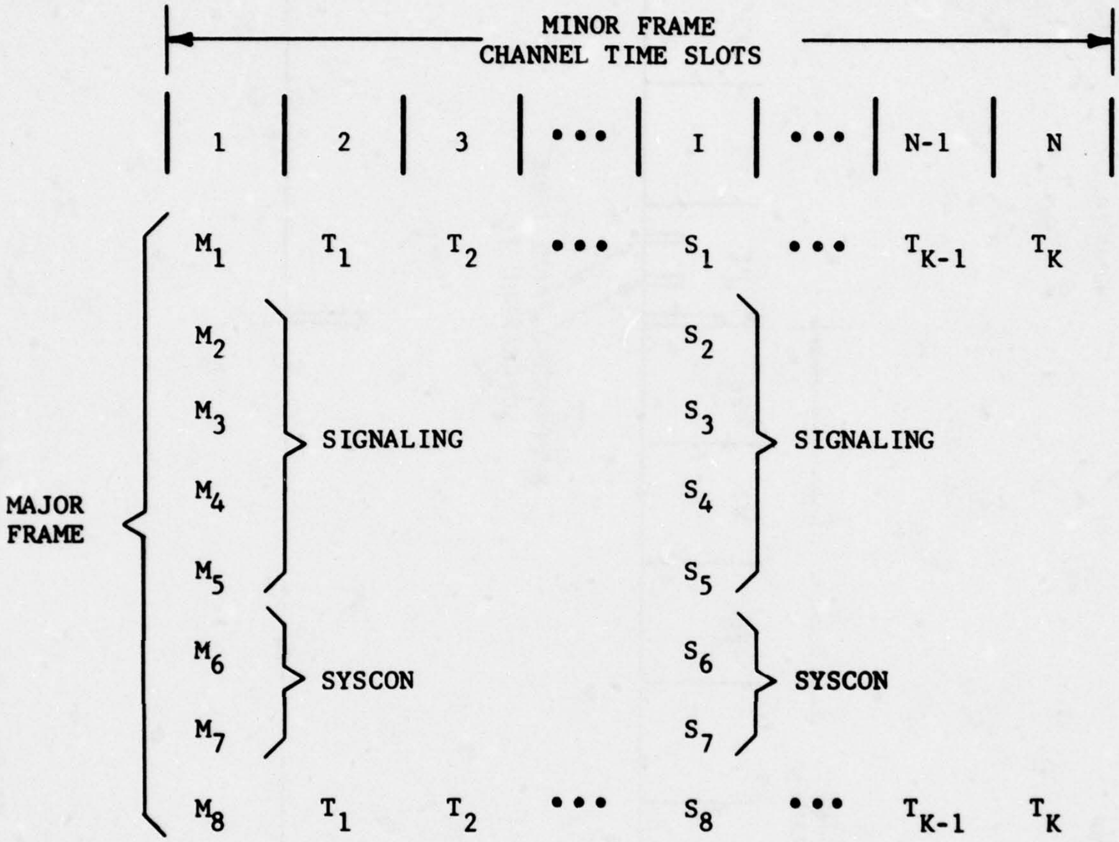


Figure 3.2-3. - Frame Definition



M = DTG OVERHEAD CHANNEL

M_1 = MASTER FRAME (1010 CODE)

S = SUBGROUP OVERHEAD CHANNEL

S_1 = FRAME (1100 CODE): TIME ALIGNED TO MASTER FRAME M_1

T = TRAFFIC CHANNEL TIME SLOT

Figure 3.2-4. - Frame Alignment

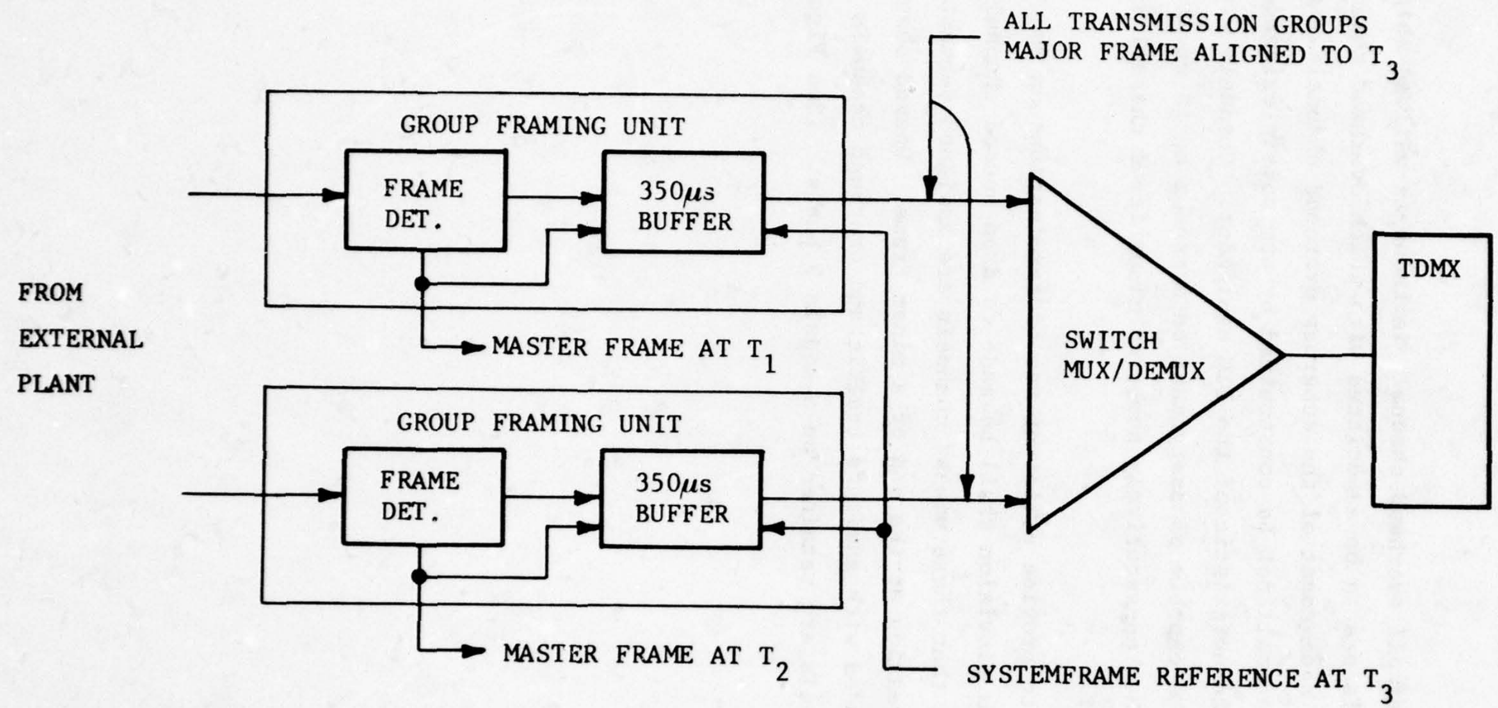


Figure 3.2-5. - Major Frame Alignment

slot location of all overhead channels is known as well as which traffic channels are to be associated with which overhead channels. The positional assignment of the subgroup overhead channels within the minor frame shall not be constrained by any multiplexing/demultiplexing characteristic of the DTG equipment. Channels within the DTG shall be capable of assignment on a random basis or in accordance with a consecutively numbered minor frame channel assignment format.

In order to provide efficient use of terminations on the Time Division Matrix provision shall be made to drop unused channels in a DTG provided that these unused channels are assigned sequentially in a block appearing at the end of a minor frame. Unused channels shall be included with assigned traffic and overhead channels such that the channels are retained on a modulo 9 basis. (See Figure 3.2-6).

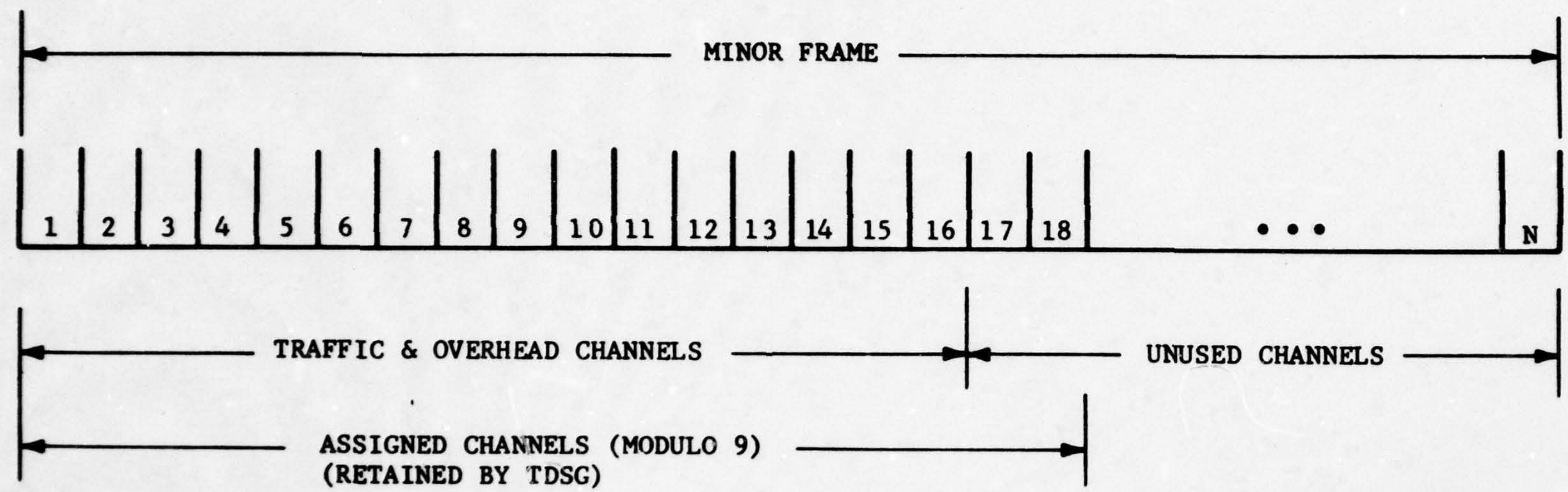


Figure 3.2-6. - Channel Assignment

APPENDIX E

AN/TTC-39 PROCESSOR I/O SPECIFICATIONS

NOTE

The contents of this Appendix is an excerpt from the AN/TTC-39 System Specification. The original paragraph, figure, and table numbering has been retained.

3.1.2 INTERFACE DEFINITION

3.1.2.1 External Interface. The CPG shall have the following external interfacing capability:

a. AC I/O channel. The AC I/O channel interface provides a channel for devices remoted from the CPG. This channel is via the AC Input/Output Exchange (IOX) (see 3.1.2.1.1).

b. DC I/O channel. The DC I/O channel interface provides a channel for local devices. This channel is associated with the DC Input/Output Expander (IOE) (see 3.1.2.1.2).

c. Power. The power interface shall provide the required voltage levels and control signal from the power supplies to associated units necessary for unit operation (see 3.1.2.1.3).

In addition, the CPG shall have an interface with the Module Test Set (MTS) and Computer Test Set (CTS). (See 3.1.2.1.4 and 3.1.2.1.5.)

3.1.2.1.1 AC I/O CHANNEL

3.1.2.1.1.1 Interface Diagrams. A simplified diagram of the AC I/O channel interface is included in Figure 2. The interface signals from the AC I/O channels are shown in Figure 3.

3.1.2.1.1.2 Interface Description. The AC I/O channel interface is between the device and the IOX networks and provides AC signals. The transfer of information shall be over 20 twisted-pair lines (see Note 6.6). The signal lines shall use transformer-coupler circuitry. A typical termination for each end of the signal line is shown in Figure 4. The signal cables shall be terminated with a terminator assembly.

3.2.1.1.3 Signals. The lines and signals of the I/O channel shall be as follows:

a. Information lines (bidirectional, bused). Nine lines shall be used for the purpose of transmitting information between the channel and devices. The nine lines shall be used for the following functional purposes:

(1) Data signals. Information lines 0 through 7 shall contain the data byte. Information line P shall provide odd parity on the eight information lines during the data transmission phase of communication. When word transmission is used, four bytes shall be transmitted sequentially (each with parity). For byte transmission, a single byte is transmitted as a

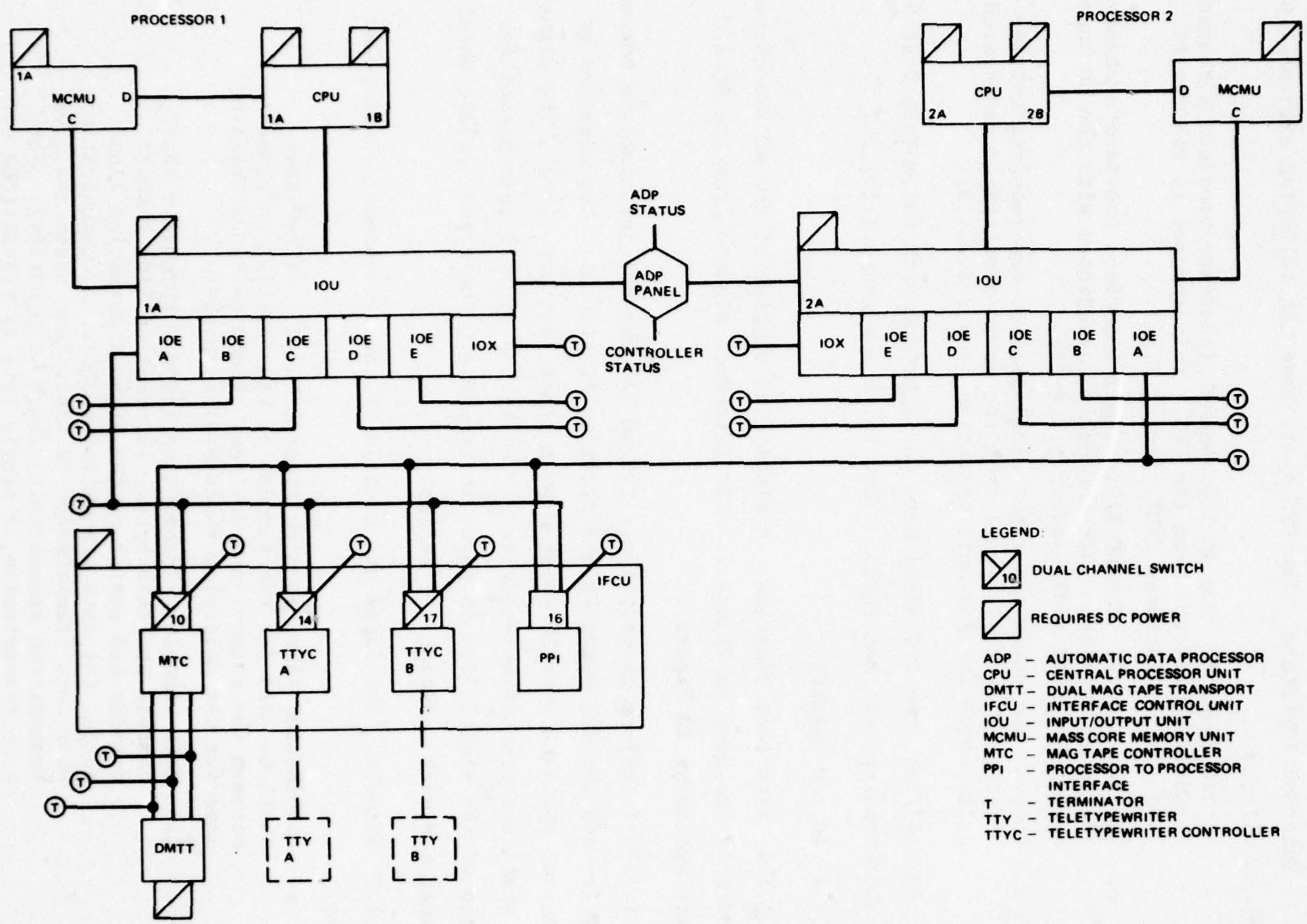


Figure 1. Circuit Switch Block Diagram

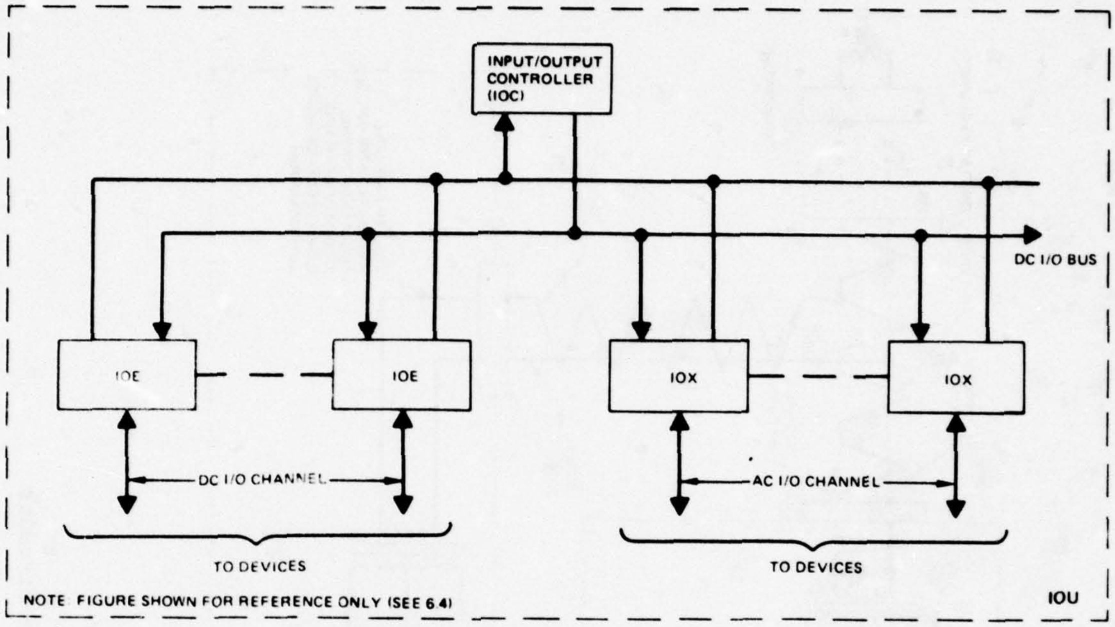


Figure 2. I/O Interfaces

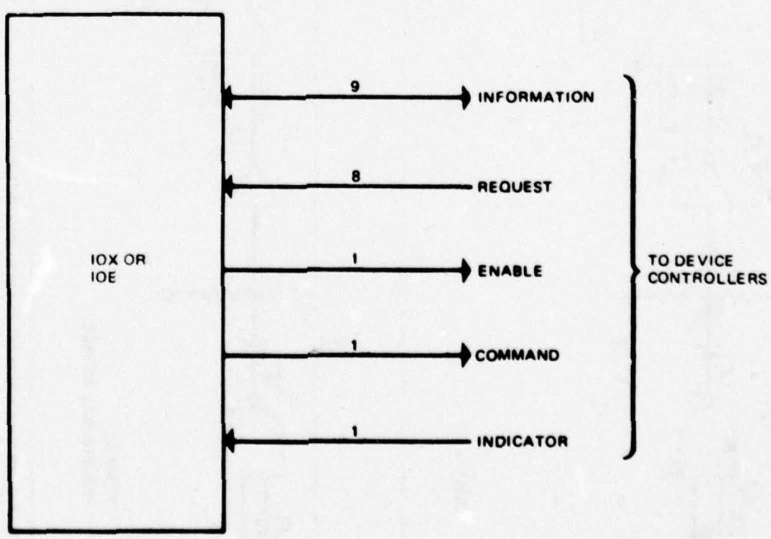
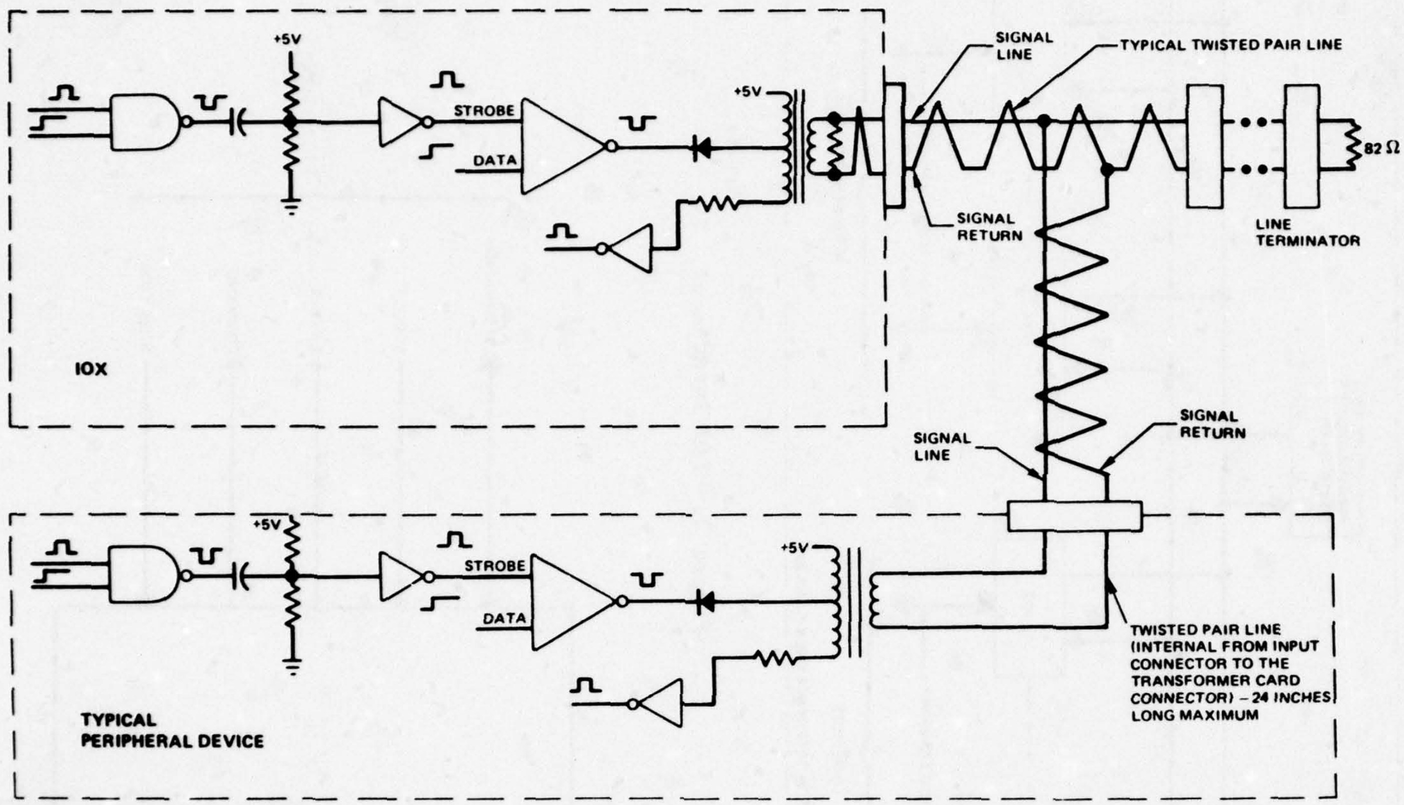


Figure 3. I/O Channel Interface Signal Lines



NOTE: FIGURE SHOWN FOR REFERENCE ONLY (SEE 6.4)

Figure 4. AC Interface Circuits

result of data transfer sequence. The most significant byte shall be transmitted first in word transmissions (bits 0 through 7, followed by 8 through 15, 16 through 23, then 24 through 31).

(2) Address selection. The eight lines (0 through 7) shall be used in conjunction with the Enable line or Command line to select a particular peripheral device. The device will be selected if the Address Selection line corresponding to the device's address switch setting is pulsed coincident with an Enable or Command signal. Information line P shall not be pulsed to indicate odd parity during the address selection phase.

(3) Device control. The Information lines shall be used to signify specific operational actions to be performed by the device. The information appearing on the Information lines shall specify the operations to be performed (refer to Table I). Information line P shall be pulsed to indicate odd parity during the control selection phase.

b. Request Lines (to computer). Each channel shall contain eight Request lines. One of the eight Request lines shall be assigned to each functional device connected on that channel. The Request line utilized by a particular device shall correspond to the device address selection setting on that device.

c. Enable line (from computer). The Enable line shall be used in conjunction with the Information lines to perform address selection. When this signal appears, the transfer of information that follows shall consist of either data flowing between the computer and peripheral devices or a device interrupt. This signal shall also be used in conjunction with the Command line to signify a Master Reset.

d. Command line (from computer). The Command line shall be used in conjunction with the Information lines to perform address selection.

Table I. Device Control Format on Information Lines

BITS PRESENT DURING CONTROL PHASE	FUNCTION
0 and 3	Device Command (DEV)
0 and 4	Output from Register (OFR)
0 and 5	Input to Register (ITR)
0 and 6	End of Block (EOB)
0 and 7	Device Stop

When the command signal appears, the information byte that follows the signal shall be an encoded command operation as shown in Table I. Further information flow shall be predicated upon the actual command issued as described in 3.1.2.1.1.4. The Command line shall also be used in conjunction with the Enable line to signify a Master Reset.

e. Indicator line (to computer). The Indicator line shall be used to acknowledge receipt of a CPU command, and to initiate a device interrupt.

3.1.2.1.1.4 Operational Sequences and Interface Timing. The operational sequences and interface timing of the signals shall be as shown in Figures 5 through 10. (To better understand the interface, refer to 3.2.1.2 for IOU characteristics.) The following requirements are applicable to the timing diagrams (Figures 5 through 10):

a. Nominal times shown are relative to source terminals.

b. Pulse width requirement for all signals is 180 $\pm$ 30 nanoseconds.

c. Sequential pulses from a common element or on the same line shall be separated by at least 400 manoseconds.

d. Changes in relative timing due to variations in gate delays and line lengths shall not exceed 80 nanoseconds after transmission on a 100-meter communication line.

e. → Transmission is from computer to device.

f. ← Transmission is from device to computer

g. The memory priority delays are assumed to be negiigible for the timing diagrams shown. The delay period could be as high as 2.3 microseconds if a programmed operation were addressing the same memory bank.

h. The functional use of Information lines shall be as follows:

   (1) (A) Represents address information
   (2) (C) Represents control information as defined in Table 1.
   (3) (D) Represents data. (At least one bit is a ONE in each byte.)
   (4) An asterisk (*) represents additional data bytes for word transmission.

i. t_{CA} is command acknowledge time ($0 < t_{CA} < 5$ microseconds at the device). (Refer to Figure 5.)

j. The program load function shall be implemented with a specific Device command (DEV) sequence. A master reset shall precede the program loads. (Refer to Figures 5 and 10). The computer will send the DEV dequence to the device no earlier than 750 nanoseconds after the master reset occurs. The T_{mr} is equal to, or

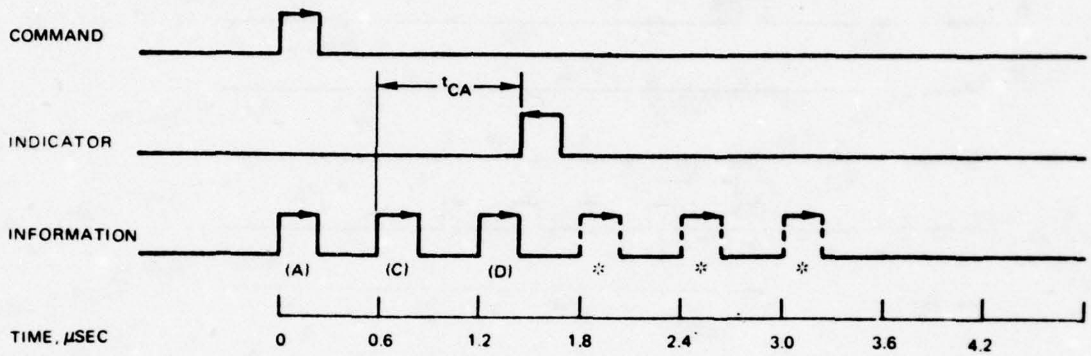


Figure 5. Command Timing (DEV and OFR Instruction)

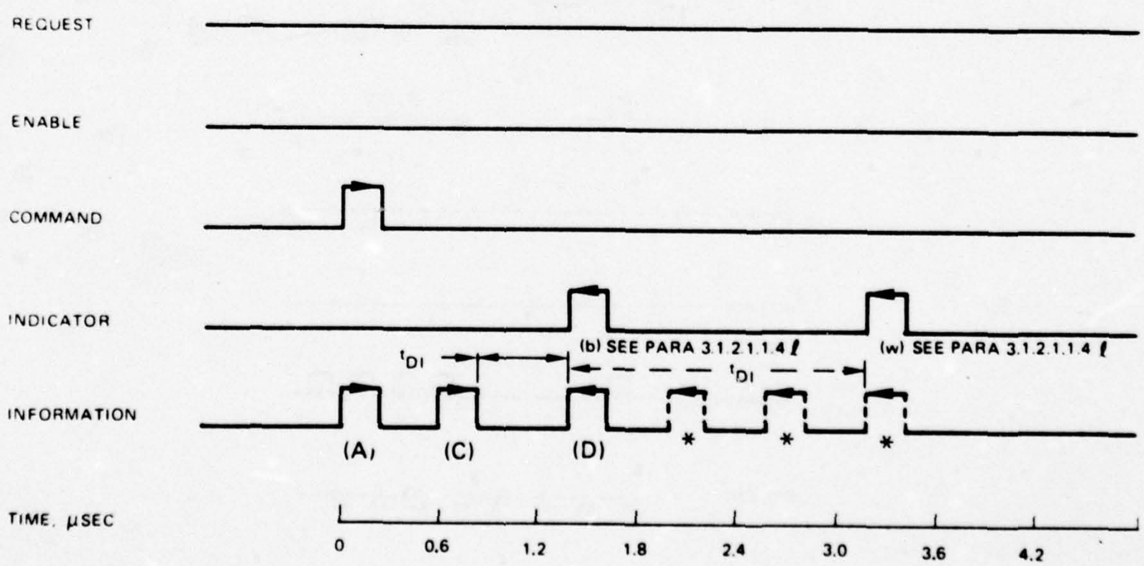


Figure 6. Command Timing (ITR Instruction)

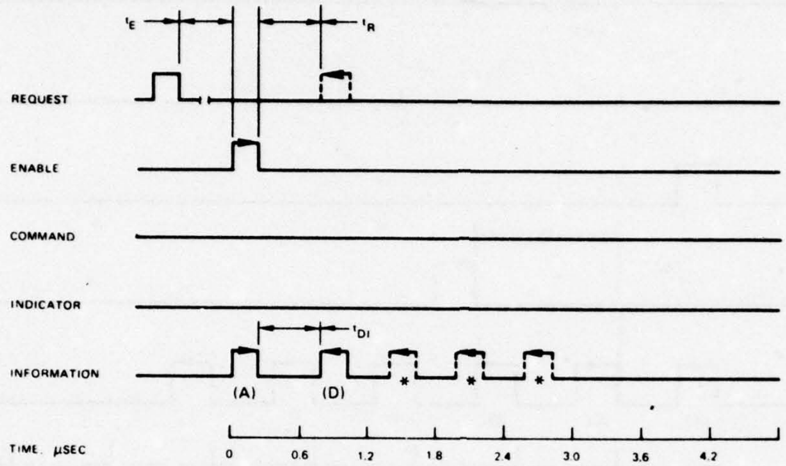


Figure 7. Automatic Input (to IOU) Timing

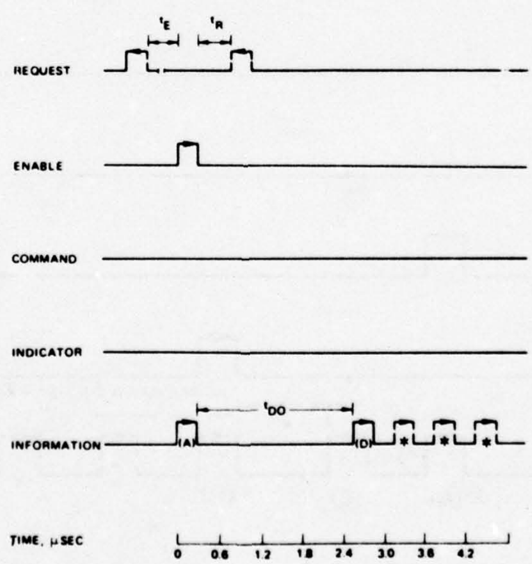


Figure 8. Automatic Output (from IOU) Timing

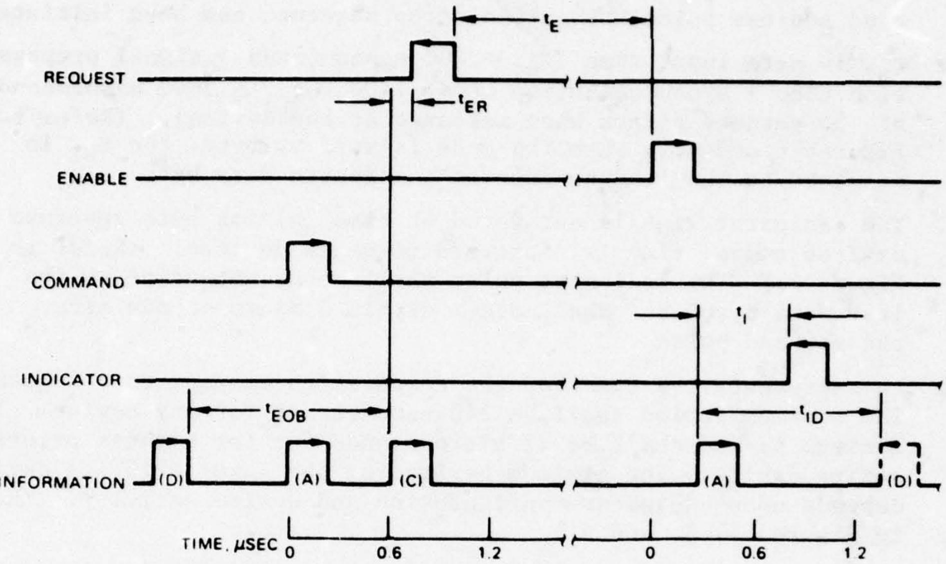


Figure 9. EOB and Device Interrupt Timing

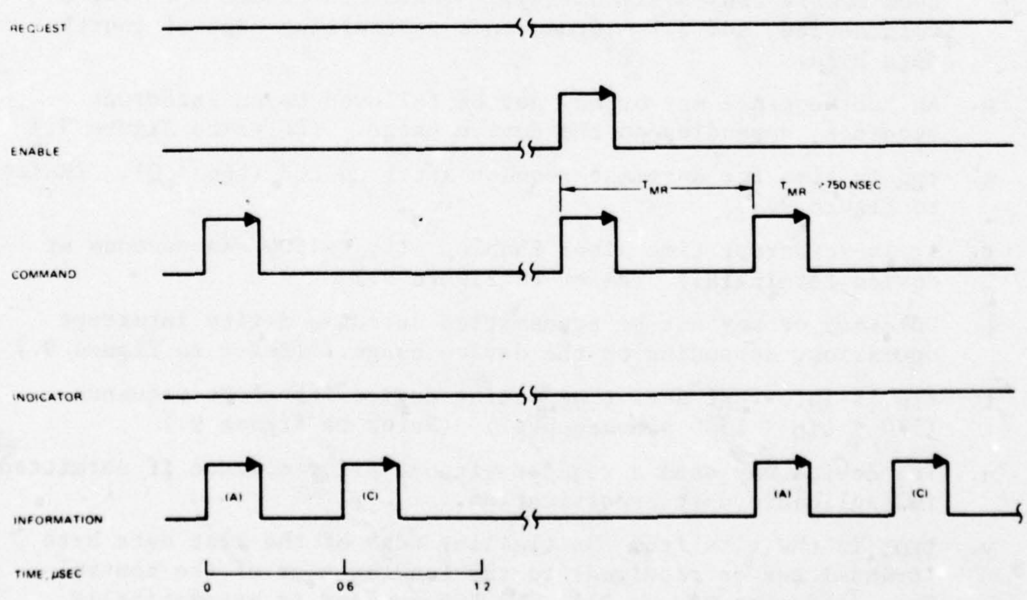


Figure 10. Device Stop Sequence and Program Load Sequence

greater than, 750 nanoseconds (refer to Figure 10). T_{mr} is the time between a master reset (command and enable) and the command address pulse when a bootstrap sequence has been initiated.

k. t_{DI} is data input time (T_{DI} = 400 nanoseconds + signal propagation time + synchronization time: $400 < t_{DI} < 5000$ nanoseconds at 50 percent points when measured at the device). (Refer to Figures 6 and 7.) When the mode is word by byte, the t_{DI} is measured to the leading edge of the fourth data byte.

l. The Indicator line is activated at time (b) for byte response devices and at time (w) for word response devices. (Refer to Figure 6.) The indicator pulse shall occur not prior to the last data byte, but shall occur within 5 microseconds after the command pulse.

m. t_E represents the time for the computer to respond to a request. The minimum period shall be 240 nanoseconds for any device. The maximum period shall be 22 microseconds for the highest priority active device. The maximum period for the lower priority device depends upon equipment configuration and device activity. (Refer to Figures 7, 8, and 9.)

n. t_R represents the time until the earliest next request from the selected device (T_R >400 nanoseconds). (Refer to Figures 7 and 8). If the device design is such that the interrupt cannot be returned immediately upon receipt of an End-of-Block (EOB) command, t_R should be greater than the time required to receive the EOB command from the IOU. (See t_{EOB} time).

o. t_{DO} is data output time ($0.4 < t_{DO} < 7.2$ microseconds, depending upon memory bank availability). (Refer to Figure 8.) For a word device, add 2.1 microseconds to trailing edge of fourth data byte.

p. An EOB sequence may or may not be followed by an interrupt sequence, depending on the device usage. (Refer to Figure 9.)

q. t_{ER} is time for earliest request after an EOB ($t_{ER} < 0$). (Refer to Figure 9.)

r. t_I is interrupt time after Enable. (t_I < 1500 nanoseconds at device terminals.) (Refer to Figure 9.)

t. Data may or may not be transmitted during a device interrupt operation, depending on the device usage. (Refer to Figure 9.)

t. t_{ID} is interrupt data time during device interrupt sequence. ($570 < t_{ID} < 1500$ nanoseconds.) (Refer to Figure 9.)

u. The device may send a request without prior command if permitted in applicable unit specification.

v. t_{EOB} is the time from the trailing edge of the last data byte (transmitted or received) to the leading edge of the control byte (refer to Figure 9). The EOB command is automatically

sent by the IOU when the key word is decremented to zero. When the IOU key word is in the output mode, t_{EOB} shall be less than 1.3 microseconds. When the IOU key word is in the input mode, t_{EOB} shall be less than 5.3 microseconds plus the delay time for device distance from the IOU. The delay time is equal to 3 nanoseconds per foot of cable distance from the IOU.

3.1.2.1.1.4.1 DEV Operation. The DEV operation consists of an address selection phase (employing the Command line) and a device control phase with Information lines 0 and 3 activated, followed by a single byte of information which is used by the device for control purposes. The device shall acknowledge receipt of this command sequence by activating the Indicator line after receiving the data byte. The timing for this sequence is shown in Figure 5.

3.1.2.1.1.4.2 Program Load Operation. The program load operation is a special form of the DEV operation. In a program load operation, a Master Reset is generated and transmitted to all devices. The DEV operation is started with the address of the device selected by a program load selector switch when a program load switch activated on the ADP Status and Control Panel. This is followed by the device control phase, and the specific data byte containing information 00001100 (bits 4, 5 = 1; bits 0-3, 6, 7 = 0). The addressed device will then enter an automatic input (to computer) communication mode.

3.1.2.1.1.4.3 OFR Operation. The Output-from-register (OFR) operation consists of an address selection phase (employing the Command line) and a device control phase (with Information lines 0 and 4 activated, followed by four data bytes which are used by the device). The device shall acknowledge receipt of the OFR command by activating the Indicator line after receiving any of the data bytes. The timing for this sequence is shown in Figure 5.

3.1.2.1.1.4.4 ITR Operation. The ITR operation consists of an address selection phase (employing the Command line) and followed by a device control phase (employing Information lines 0 and 5, followed by one to four data bytes generated by the device). The device activates the Indicator line when sending the last data byte. The timing for this operation is shown in Figure 6.

3.1.2.1.1.4.5 Automatic Input (to IOU) Operation. The automatic input operation is initiated by a request from the device. At the convenience of the computer, an address selection phase employing the Enable line occurs. The

device will then transmit one to four bytes. The timing for this sequence is shown in Figure 7.

3.1.2.1.4.6 Alarm Operation. The alarm operation is used by the computer to count events which are represented by a device request. The computer acknowledges the device request with an address selection phase employing the Enable line. The alarm operation is similar to that shown in Figure 7, except there shall be no data transfer. A peripheral device that uses this mode may generate an interrupt sequence if the indicator signal is returned less than 700 nanoseconds after the Enable signal.

3.1.2.1.1.4.7 Automatic Output (from IOU) Operation. The automatic output operation is similar to that described in 3.1.2.1.1.4.5, except that data is transmitted from the IOU to the device. The timing sequences for this sequence is shown in Figure 8.

3.1.2.1.1.4.8 EOB Operation. The EOB operation consists of an address selection phase (employing the Command line) followed by a device control phase (employing Information lines 0 and 6). If the device is to interrupt the computer, the device may send a request any time after recognizing the device control information. The timing for this sequence is shown in Figure 9.

3.1.2.1.4.9 Device Interrupt Operation. The device interrupt operation may be initiated after an EOB sequence or as a result of a specific action. The operational sequence is started with a request from the device. At the convenience of the computer, an address selection phase employing the Enable line occurs. The device then activates the Indicator line. If required, the device may transmit a data byte as shown in Figure 9. The computer shall not check parity on the data byte. A device interrupt operation for a device operating in the Alarm mode shall return the indicator signal within 700 nanoseconds of the Enable signal.

3.1.2.1.1.4.10 Device Stop Operation. The device stop operation consists of an address selection phase (employing Command line) followed by a device control phase (employing Information lines 0 and 7). The sequence is generated by the computer when an illegal or erroneous condition occurs as related to a particular device. The illegal or erroneous condition may occur after a request for service from a device for an automatic input or output operation. When the device

detects this operation, the device reverts to its standby state. The addressed device shall respond to a device stop operation in a manner identical to a Master Reset operation. The timing for this sequence is shown in Figure 10.

3.1.2.1.1.4.11 Master Reset Operation. The Master Reset Operation occurs whenever the Command line and Enable line are active simultaneously. The address (Information) lines are not activated during a Master Reset operation. All devices ignore the address lines during the Master Reset operation. When the device detects this operation, the device reverts to its standby state, and shall not send a Request nor an Indicator signal to the computer. A master reset occurs as defined in 3.1.2.1.1.4.2 and on power turn-on.

3.1.2.1.1.5 Interface Circuits and Signal Characteristics. The computer shall be connected to external devices on the interface (see Figure 4). All lines shall be twisted-pair, signal and return lines. Each signal line shall be terminated by a resistor in the computer and at the remote end of the line. Each signal line shall be capable of servicing eight elements in addition to the controlling element.

a. Current convention. The interface circuits and signal characteristics shall conform to the following: The signal currents shall be conventional currents, flowing from positive to negative potentials. A positive current indicates that the circuit is supplying current. A negative current indicates that the circuit is receiving current.

b. Logic levels. The logic levels for the I/O communication channel shall be as follows:

   (1) A logical 1 shall be a pulse having a pulse width greater than 120 nanoseconds and a amplitude greater than 3 volts.

   (2) A logical 0 shall be a signal not exceeding 0.5 volt on a Communication line.

c. Drive circuit (electrical operation). A drive circuit shall function to supply data or control information to a communication cable. The drive circuit shall convert logic signal inputs to the appropriate level for transmission over the twisted-pair communication lines.

d. Receive circuit (electrical operation). A receive circuit shall function to detect data or control information from a communication cable. The receive circuit shall convert the transmitted signal to a level compatible for logic operation.

e. Data transfer. The peripheral devices remain insensitive to data on the Information lines until an address selection phase for that device occurs. All data transfer contains at least one bit per byte. The transfer method allows the data to be self-clocking by utilizing a data strobe formed by ORing contents of the Information lines. The pulse dispersion on the Information lines is shown in Figure 11.

3.1.2.1.1.6 Mechanical Interface. The signal connector on the device for connection to the computer I/O channel shall be a 55-pin connector or an 80-pin card slot connector.

3.1.2.1.2 DC I/O CHANNEL

3.1.2.1.2.1 Interface Diagram. A simplified diagram of the DC I/O channel interface is included in Figure 2. The interface signals for the DC I/O channel are shown in Figure 3.

3.1.2.1.2.2 Interface Description. The DC I/O channel interface is between the device and the Input/Output Expander (IOE). The transfer of information shall be over 20 twisted-pair lines. The signal lines shall use DC circuits.

3.1.2.1.2.3 Signals. The lines and signals shall be as specified in 3.1.2.1.1.3.

3.1.2.1.2.4 Operational Sequences and Interface Timing. The operational sequences and interface timing shall conform to 3.1.2.1.1.4.

3.1.2.1.2.5 Interface Circuits and Signal Characteristics. The interface circuits and signal characteristics shall conform to the following:

a. Current convention. The signals shall be conventional currents, flowing from positive to negative potentials. A positive current indicates that the circuit is supplying current. A negative current indicates that the circuit is receiving current.

b. Logic levels. The logic levels for device communication signals shall be as follows:

   (1) A logic 1 shall be less than 0.5 volt.

   (2) A logic 0 shall be greater than +3.0 volts.

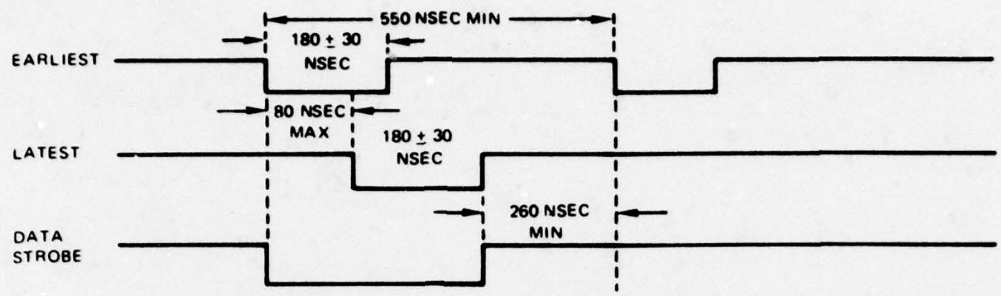


Figure 11. Information Line Pulse Dispersion

c. Drive circuit (electrical operation). The drive circuit shall supply data or control information to a communication cable. The drive circuit shall convert logic inputs to the appropriate levels for transmission over the twisted-pair communication lines.

d. Receiver circuit electrical operation. The receiver circuit shall detect data or control information from a communication cable. The receive circuit shall convert the transmitted signal to a level compatible for logic operation.

e. Cable length. The cable length between an IOE and a device shall not exceed 50 feet.

APPENDIX F

AN/TTC-39 INTERFACE CHARACTERISTICS

ANALOG LOOPS

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
TA-341	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Supervision	25-50 ft	DTMF Signaling, 570 Hz Ringing, AC or DC Supervision, ± 12 V Required
TA-720 (Same as TA-341 Except Precedence Keys Included)	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Supervision	25-50 ft	Same as Above
TA-236	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	Out-of-Band Signaling/ Supervision	25-50 ft	20 Hz Ringing, DC Loop Supervision, Dial Pulse Signaling, 40mA Current Source Required, 80 ± 10 Vrms 20 Hz Signal Required.
WECO 2500 (Same as TA236 Except DTMF Signaling Instead of DIAL Pulse)	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Out-of-Band Supervision	25-50 ft	20 Hz Ringing, DC Loop Supervision, DTMF Signaling, 40 mA Current Source Required, 80 ± 10 Vrms 20 Hz Signal Required
TA-312	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Out-of-Band Supervision	25-50 ft	Current Source of at Least 40 mA Required, Shall Detect a Signal of 12-25 Hz, 25-110 Vrms. Ring Signal of 20 ± 5 Hz, 80 10 Vrms Required
AUTOVON	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Out-of-Band Supervision	25-50 ft	40 mA Current Source Required, DC Supervision, DTMF Signaling
CONUS and OVERSEAS AUTOVON	Analog	4 kHz		Baseband	None	Tones -7 to -24 dBm	In-Band Signaling/Supervision	25-50 ft	SF Supervision, DTMF Signaling

ANALOG LOOPS (CONT.)

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
Narrowband Subscriber Terminal (NBST)	Analog	2400 Baud			None		In-Band Signaling/Supervision	4 km Max.	2600 Hz Supervision and DTMF Signaling
KY-3	Analog	50 kb/s		Baseband or Diphase	None	Tones -4 to -31 dBm		4 km Max.	2600 Hz SF Signaling

ANALOG TRUNKS

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
AN/TTC-25, 30, 38	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	In-Band Signaling/Supervision		AC Supervision (2250/2600 Hz) DTMF Signals (25, 30, 38 Appears as a TA-341
AN/TTC-22, 28	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	Out-of-Band Signaling/ Supervision		2 Wire DC or 4 Wire SF (2600 Hz) Supervision DIAL Pulse Signaling, Appears as a TA-236. When using SF, Interface appears as a TA-236.
COMMERCIAL PBX (1 Way Automatic, 1 Way)	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	In-Band Signaling, Out-of-Band Supervision		DC Loop Supervision, High Voltage 20 Hz Ringing, DIAL Pulse Signaling
4 Wire, SF, DIAL Pulse									2600 Hz SF Supervision, DIAL Pulse Signaling
(E&M Interface)									Employs E&M Supervision, DIAL Pulse or MF Signaling, E&M Requires -48 Volts
AN/TTC-4,5,7, 10	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	Out-of-Band Signaling/ Supervision		Appears as a TA-236
SB22, SB86	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	Out-of-Band Signaling/ Supervision		20 Hz Ringdown Supervision Transmit 80 ± 10 Vrms, 20 ± 5 Hz, Receive 25-110 Vrms 12-25 Hz
SB3082 (CO & 1600 Hz Ringdown Trunks)	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	Out-of-Band Signaling/ Supervision		Transmit 1600 Hz ± 2% -7 dBm

ANALOG TRUNKS (CONT.)

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
SB 3614-CV2907	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm	In-Band Signaling/Supervision		AC Supervision, DTMF Signaling same Characteristics as TA-341
CV1918,1919 2875	Analog	4 kHz		Baseband	None	Tones: -7 to -24 dBm			Changes 20 Hz Ringdown to 1600 Hz SF Supervision and Vice Versa
ANALOG SATELLITE (Tone Burst Trunk)	Analog	4 kHz		Baseband	None		In-Band Signaling/Supervision		AC Supervision, DTMF Signaling
1600 Hz Ringdown Trunk	Analog	4 kHz		Baseband	None				1600 Ringdown Supervision
AUTOVON TRUNK/ PBX	Analog	4 kHz		Baseband	None	Tones: 0 to -22 dBm	In-Band Signaling, Out-of-Band Supervision		2600 Hz, SF Supervision
NATO Interface	Analog	3 kHz		Baseband	None	-4 dBm Test Tone	Out-of-Band Signaling/ Supervision		DC Supervision, Dial Pulse Signaling, +24 $\pm$ 5% Vdc, Also uses 2000 Hz Supervision

DIGITAL LOOPS AND TRUNKS

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
LOOPS									
TENLEY Subset (DSVT)	Digital	32 kb/s		Conditioned Diphase	None	3 Vpp ± .3 V	In-Band Signaling/Supervision		2600 Hz SF Supervision
TSEC/KY-68									
DNVT (Same as DSVT w/o (Security)									
TRUNKS									
DIGITAL SATELLITE	Digital	256 kb/s 2.304 Mb/s		Conditioned Diphase	TDM	3 VPP ⟶ 90 Vrms ± 10%	In-Band Signaling/Supervision	1.61 km w/o Repeaters	
TD754, TD204, AN/GRC-143	Digital	2.304 Mb/s		Dipulse	TDM	Logic "1" = 1.6-2 V	In-Band Signaling/Supervision		Pulse Width 180-230 ns
TTC-39 Interswitch Trunk	Digital	256 kb/s-2.304 Mb/s		Conditioned Diphase	TDM				

CIRCUIT SWITCH INTERSHELTER CABLING

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
Processor I/O Channel	Digital	@1.7 Mb/s	33%	Baseband	None	"0" - .5 V Max. "1" - 3 V Min.		100 Meters	None
Engineer Orderwire Intercom	Analog/ Digital	32 kb/s		Baseband and Conditioned Diphase	None	3 Vpp ± 10%			1600 Hz Signaling and Supervision
TTY Interface	Digital	300 b/s			None	± 5 Vdc			
LKG Red & Black Interface	Digital	32 kb/s		Baseband	None	± 3 Vdc	Data: Risetime >1.25 μs<3 μs Clock: >.3 μs <1.25 μs		None None
TENLEY Control Lines	Digital	32 kb/s		Baseband	None	0 to -3 Vdc	Data: Risetime >1.25 μs <2.5 μs Clock: >.3 μs <1 μs		
Digital Subscriber Voice Terminal	Digital	32 kb/s		Conditioned Diphase	None	.15-4Vdc			24-56 Vdc Required (62 mA)
Call Service Position to Switching Modules	Analog/ Digital	4 kHz 16/32 kb/s		Baseband Diphase	None None				None

MESSAGE SWITCH ANALOG AND DIGITAL INTERFACES

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
DATA TERMINAL EQUIPMENT	ANALOG								
	Line Type 1	45.45 to 600 baud	7/8 bit ITA No. 2	Modem Type 1 - FSK (≤150 baud)	None	Input -45 to +7 dBm Output +3 to -10 dBm	Asynchronous, 4 Wire		Full Duplex (FDX)
	Line Type 2	75 baud to 4,800 baud	10/11 bit ASCII	Modem Type 1 - FSK & Diphase Modem	None None	Same as Above Output 3 Vpp ± 10%	Asynchronous, 4 Wire		Simplex (SPLX) Full Duplex/Automatic Repeat Request (FDX/ARQ)
	Line Type 3	75 to 32 k baud	8 bit ASCII	Modem Type 2- FSK & Diphase Modem	None None	Input 0 to -30 dBm Output -10 to +6 dBm Output 3 Vpp ± 10%	Synchronous, 4 Wire Synchronous, 4 wire		FDX/ARQ HDX/ARQ
	Line Type 4	45.5 to 32 k baud	8 bit or 11 bit ASCII or ITA No. 2	Modem Type 2 - FSK & Diphase Modem	None None	Same	Asynchronous		FDX/ARQ, HDX/ARQ FDX/SPLX, FDX/ARQ
MSG SWITCH TO MSG SWITCH TRUNKS	Digital								
	Line Type 3 Or Line Type 4	1200 to 32 kb/s		Diphase Modem	None	Output 3 Vpp ± 10%	Synchronous		Full Duplex
AUTODIN to MSG SWITCH TRUNKS	Digital								
	Present	1200 to 4,800 b/s	8 bit VSACII	FSK MD-701/KG13 SN 394 or MD701/KG30	None		Synchronous		Full Duplex
	Future	16 k & 32 kb/s		Diphase Modem	None	3 Vpp ± 10%			
CIRCUIT SWITCH TO MSG SW. TRUNKS	Digital	128 to 576 kb/s		Diphase Modem	TDM		Synchronous		Full Duplex, Common Channel Signaling

MESSAGE SWITCH ANALOG AND DIGITAL INTERFACES (CONT.)

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
	Analog								
	Line Type 1 Type 2 Type 3	45.45 to 16k band No. 2 & AGCII	7 to 11 bit ITA	FSK	SDM		Asynchronous and Synchronous		FDX, SPLX, HDX, ARQ
	Subscrib-ers	4 kHz	—	—	SDM				Signaling on Common Channel via the Digital Overhead Channel

MESSAGE SWITCH INTERSHELTER CABLING

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
IOX LINES	Digital 20 Pair Twisted Wire Total	1.67 MHz Burst Max.	Pulse Width: 180 ± 30 ms Min. Pulse Separa tion: 400 ms Max. Duty Cycle = 1/3	AC	—				—
Information Lines — 0-7	Bidirec- tional Bus	(Very Active)			—	Logical 1: 4.5 ± 1.5 V & Pulse Width 180 ms	Compelled Responses	100 Meters Max.	—
Parity Lines — 8	Bidirec- tional	(Active)			—	Logical 0 :.25 ± .25V			—
Request Lines — 9 — 16	Dedicated	(Moderate- ly Active)			—				—
Enable Line —17	Uni- direction	(Moderate- ly Active)			—				
Command Line —18	Uni- direction	(Moderate- ly Active)			—				—
Indicator Line —19	Uni- direction	(Moderate- ly Active)			—				—
CONFIGURATION & ALARM PANEL INTERFACES									
CAP to CRSM (Configuration Register & Status Multi- plexer)	Digital 1 Line	STATIC LEVELS	—	Balanced Differential	—	+.3 to +3 V Diff. is logic One -.3 to -3 V is logic zero	Selection Function		
CRMS to CAP	Digital 1 Line	STATIC LEVELS	—	Balanced Differential	—	+.3 to 3 V dif is logical one -.3 to -3 V dif is logical zero	Status Info		

MESSAGE SWITCH INTERSHELTER CABLING (CONT.)

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
CAP to CAL (Communication Inter. PROC/ Message PROC Link)	Digital 2 Lines	STATIC LEVELS	—	Balanced Differential	—	+.3 to 3 V diff. is logical one -.3 to -3 V diff. is logical zero	Selection Function		
CML to CAP	Digital 2 Line	STATIC LEVELS	—	Balanced Differential	—	+.3 to 3 V diff. is logical one -.3 to -3 V diff. is logical zero	Status Info		
CIS Summary Alarm (Communic. Inter. Shelter)	Digital 1 Line	Static	Logic Level	—	—	Active (Alarm) - Open Circuit Inactive (No Alarm) - Closed Circuit	—	100 ft	—
COMMUNICATION GROUP INTERFACE									
DSVT (From CIS to MPS)	Digital 2 Lines	32/16 kb/s	50% Max.	Conditioned Diphase	—	Xmitter: 3 Vpp $\pm$ 10% @ 125 Ω .65 $\longrightarrow$ 1.95 ms Risetime Recvr: 170 mV $\rightarrow$ 4 Vpp	Codeword Signaling and Supervision	100 ft	Short circuit Current - $\pm$ 40 mA +28 V Source
TA-341	Analog 1 Line (4 Wire)	4 kHz	—	—	—	—	DTMF Signal-ing and Supervision	100 ft	—
Engineering Order Wire (TBD)	—	—	—	—	—	—	—	100 ft	—
INTERCOMS	Analog (2 Wire)	4 k	—	—	—	—	—	100 ft	115 Vac, 50-400 Hz 3 Wire 3 W Standby 10 W Peak Xmitting

MESSAGE SWITCH INTERSHELTER CABLING (CONT.)

SIGNAL NAME	TYPE	FREQUENCY	DUTY CYCLE	MODULATION TYPE	MULTIPLEXING METHOD	SIGNAL LEVEL	PROTOCOL	PHYSICAL LENGTH	SIGNAL & POWER CONSIDERATIONS
TTY INTERFACE (BUFFER/ BUFFER)	Digital 3 Lines (4 Wires)	Serial Data Type 1,2, 3, or 4 Line Types 300 b/s both XMIT & RCV	—	Differential	—	.0 to +.8 = "1", + 2.5 to +5.0 = "0"	—	—	—